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OF

OPHTHALMOLOGY

AND

OTOLOGY.

EDITED IN ENGLISH AND GERMAN

BY

PROF. H. KNAPP, M.D.,
OF NEW YORK,

PROF. S. MOOS, M.D.,
OF HEIDELBERG,

AND

PROF. L. MAUTHNER, M.D.,
OF VIENNA,

IN CONJUNCTION WITH

DR. E. GRUENING, OF NEW YORK, AND DR. CL. J. BLAKE,
OF BOSTON.

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OPHTHALMOLOGICAL PART.

RESEARCHES ON THE MICROSCOPICAL STRUCTURE OF THE CORNEA.

By WILLIAM HASSLOCH, of New York.

(With five drawings.)

It is generally acknowledged that the substantia propria of the cornea is made up of fibrils united into fascicles; that the majority of these bundles, by being more or less parallel to the surface of the cornea, form the laminated structure of the latter, at the same time crossing one another, and so giving rise to a kind of a lattice-work; while other fibres and bundles traverse the cornea in various directions. The fibrils, as well as the fascicles and lamellæ, are connected with one another by an intermediate cement substance, which somewhat differs from the fibrils in its chemical reaction.

But, concerning the relation of the protoplasm to the basis-substance, observers are of very different opinions. Some of them do not admit the existence of the protoplasmic bodies at all, asserting that within the basis-substance of the cornea only a tubular system is present, lined with "cell-plates." Other histologists hold the view that there is a certain quantity of protoplasm (cells of the cornea) inclosed in the "serous spaces," in which it ramifies, but which it does not completely fill. One of the most prominent advocates of the latter opinion is *W. Waldeyer* (article Cornea in *Graefe-Saemisch's* Handbook, 1874), deriving his views chiefly from the results of injections made by him and other recent observers into the tissue of the cornea. Fluids, pressed into the corneal parenchyma, produce, indeed, ramified figures resembling the "corneal corpuscles." *W. Kuehne*, *S. Stricker*, and *A. Rollett* state that there are complete corneal cells with protoplasmic bodies, with nuclei and nucleoli within the ramifying spaces, and that they fill these spaces completely. *W. Engelmann* denies the existence of preformed spaces inclosing corneal cells, etc. He states that there are spaces containing nothing but protoplasm, and this is in my opinion the only correct view, as I shall endeavor to prove.

In order to study the relation of the protoplasm to the basis-substance, I chose the cornea of the dog and of the cat, giving preference, after repeated trials, to that of the cat, as has previously been done by S. Stricker, on account of its easy splitting. With some practice one may succeed in obtaining lamellæ which present two or even only one layer of corneal corpuscles, and which, therefore, are sufficiently transparent to admit of being examined even with the highest powers of the microscope.

To stain the cornea, I at first tried nitrate of silver. The cornea of a cat was taken out immediately after death, and was put into a two-per-cent solution of nitrate of silver for one-half to one hour; then it was washed with distilled water, and, finally, for several days left under the influence of a very mild dilution of acetic acid. Instead of the acetic acid, in later experiments, I substituted lactic acid, which proved even more satisfactory than the former. After being prepared in this way, the cornea of the cat was ready to be split into lamellæ. The specimens were mounted with equal parts of glycerin and water.

With enlargements of 300–500 such lamellæ show on a dark ground—basis-substance—light fields with numerous connecting branches, generally known as *von Recklinghausen's* serous canaliculi; and even an enlargement of 500 is sufficient to prove that the outlines of these light spaces do not appear smooth at all, but granular, viz., abundantly perforated, and that the brown or gray-brown looking basis-substance is finely granular.

With higher powers (immersion lenses with enlargements of 800–1,200) the following facts (Fig. 1) are observed: Within the light spaces oblong nuclei with very faint contours and a great number of extremely pale granules are visible. The light spaces are connected with their neighbors by light processes of various sizes, traversing the basis-substance. The borders of these light fields and of their branches are abundantly perforated, like a sieve, throughout, so that true outlines do not exist. Fine, light tracts run from every light space, and its branches through the basis-substance, profusely ramifying and anastomosing, sometimes radiating, and thus forming an extremely delicate, light network, the threads of which traverse the basis-substance in all directions and connect with the light fields and their processes at the whole circumference. What with lower power was recognized as granular structure was by higher enlargements elucidated as a very fine, light network, the meshes of which are filled by the dark-brown basis-substance.

On thin transverse sections (Fig. 4), the silver-stained cornea of the cat shows the same ramifying light fields as on split preparations, with the only difference that their vertical diameters are notably smaller, while their horizontal diameters are the same as those of the light fields of the lamellæ. The light spaces branch out in all directions, so that not only the light fields of the same stratum are connected with each other, but even those of different layers anastomose by ascending and descending—more or less oblique—processes. Besides these ramifications, especially in the outer strata of the cornea, some fine, straight, light lines are met with, which, for reasons given below, are proved to be nerve-fibres. Even on transverse sections the whole brown basis-substance is traversed by light, ramifying tracts to such an extent that the cement-substance cannot be distinguished from the other components of the cornea.

Further, I tried to stain the cornea of the dog and of the cat with chloride of gold. Many experiments which I made failed, though I had exposed the cornea to the influence of the chloride of gold for hours. The after-treatment with acetic acid and with tartaric acid gave only negative results. I could never see any distinct pictures of the corneal corpuscles with their ramifications until, at last, by the aid of lactic acid, I succeeded in obtaining preparations of such beauty and of such clearness, that all doubt with regard to the finest structure of the cornea disappeared.

My method is the following: The cornea of a cat is taken out immediately after death, soaked in a ten-per-cent solution of lactic acid, and for a period of about twelve hours, then during one or two hours it is kept in a one-half-per-cent solution of chloride of gold, slightly acidulated by the addition of a few drops of lactic acid, and finally exposed to the influence of daylight. The superficial strata of the cornea and a peripheral border of 1 mm. turn yellow, and are of no use for examination, but the other part, the characteristic purplish tint of which shines through the yellow envelope, is invaluable for research.

After having made the above-described experiments, I learned that *J. S. W. Arnold*, of New York, had previously used lactic acid for the reduction of chloride of gold; but he informed me that his method differs from mine, inasmuch as he uses the chloride of gold in the first stage of the preparation, followed by the lactic acid, just the reverse of my plan of treatment.

The cornea of the cat, prepared after my method, splits readily, and its lamellæ, after turning dark enough by the influence of daylight, appear under the microscope throughout their whole extent strewn over with numerous, richly-ramifying, dark-violet corpuscles; in many of the latter the nuclei are distinctly visible; the corpuscles themselves crowded with dark granules; the basis-substance light, pale-violet, and also having a granular appearance. I have searched through a great many lamellæ, but I have never found any corpuscles that did not shoot off into branches; everywhere and always I met with only ramifying, dark-violet corpuscles with numerous connections and in different strata of varying sizes. The dark-violet fields fully coincide with the light spaces of the silver-stained cornea as to size, figure, and connections, as has been stated by *W. Kuehne*. The only difference is that in the silver preparation light fields are visible on a dark ground, while in the gold specimen the dark corpuscles appear on a light ground—pictures which correspond with each other as the negative with the positive photograph.

Gold pictures examined with high powers (800–1,200) show that the dark-violet, ramifying corpuscles, without exception, have a retiform structure, and that the nucleoli, the contours of the nuclei, and all the granules are connected with one another by innumerable fine threads. The whole network is tinted equally dark-violet, while its extremely narrow meshes appear pale violet. The borders of the corpuscles and of their branches are nowhere distinct; contours in the real sense of the word are wanting in the gold picture as well as in the silver preparation, inasmuch as from the whole circumference of these ramifying, dark-violet fields, immense numbers of fine threads protrude, to join the neighboring dark-violet granules within the basis-substance. An examination of any portion of such a specimen will not fail to convince the observer that also in the basis-substance nearly all dark granules are connected with one another by fine threads. The cause of the difference between the shade of the corneal corpuscles and that of the basis-substance is, that in the former the granules are larger and lie close together, and that consequently the meshes are very small, while within the basis-substance the granules are mostly fine and more dispersed, and for this reason are separated from one another by larger meshes.

In some lamellæ, and, as it seemed to me, principally in the outer layers of the cornea, many corpuscles are connected with one another, not by broad branches, but by dark-violet, more or less straight lines, which for their characteristic, rosary-like structure must be considered non-medullated nerve-fibres (Fig. 3).

In profile (Fig. 5), the gold-stained cornea of the cat offers another proof of the coincidence of the positive gold picture with the negative silver preparation. Flat, elongated, dark-violet bodies are visible which, in the horizontal direction, anastomose with one another by means of fine, long processes; while broad, rather oblique, dark-violet branches ascend and descend to connect the corpuscles of different layers. The network of the dark fields and that of the basis-substance are shown with the same clearness as in split preparations. The laminate structure of the cornea is as imperceptible in these transverse sections as it is in those of the silver-stained cornea.

On transverse sections of the gold-stained cornea of a dog I observed, especially in the central parts of the cornea, formations, which sufficiently explain the views of *W. Waldeyer*, who maintains that the corneal corpuscles do not completely fill the "serous spaces." There I saw groups of corneal corpuscles, which leaned mainly against one of the walls of the space, while a more or less considerable portion of the latter appeared empty. A closer examination, however, proved that these apparent voids are artificial products, namely, vacuoles. It can be observed that the eccentric cavity is situated *within* the corneal corpuscle, and on its whole circumference is inclosed by the protoplasm of the corneal corpuscle. No matter how thin the stripe of protoplasm which is interposed between the vacuole and the periphery of the "serous space" may be, it is always present. It is known that such vacuoles can arise from contraction of the living matter within the protoplasm. The question, why these contractions, perhaps as a result of the action of the chloride of gold, were observed only on certain groups of corneal corpuscles, remains unsolved. On the cornea of the cat I have never met with any formations of this kind.

From these observations it clearly follows: *that a tubular system, as described by von Recklinghausen, does not exist in the cornea at all.* The light fields, which the silver pictures of the cornea show, are not "serous spaces," but protoplasmic bodies, as stated by *W. Engelmann* and others, viz., spaces which are wholly filled with protoplasm. The strongest proof of this assertion is found in the result of the method of staining the cornea with chloride of gold, improved by the treatment with lactic acid, as it exhibits the corneal corpuscles in perfectly clear pictures, which in every particular completely correspond to the negative silver pictures. Whether an interstice filled with fluid remains between the wall of the so-called serous space and the protoplasmic body, or not, I will not yet venture to decide; but as the protoplasm itself contains a considerable amount of fluid, it is not at all necessary to admit the presence of peripheral cavities filled with serum. Wherever an interspace between a corneal corpuscle and the wall of the "serous space" can be observed, its presence depends upon the formation of a vacuole, and cannot, therefore, be maintained in opposition to my view. Nor do the parenchymatous injections prove anything contrary to it; for it is apparent that colored fluids, which are forced into the protoplasmic spaces, will press the soft protoplasmic bodies against the walls of such spaces, and thus assume the principal forms of the latter.

My observations further show that the protoplasm of the corneal corpuscles has a retiform structure, which can be evidently demonstrated by the above-described method of staining the cornea with chloride of gold. The question, whether this method be an artefact or not should no longer be a matter of dispute, since, on the creeping amœba, on colorless blood-corpuscles, and on pus-corpuscles the same network has been demonstrated, and by photography made visible even to the naked eye. That this network (nucleoli, outline of the nucleus, granules, and connecting threads) is the living matter, the meshes of which inclose the lifeless protoplasmic fluid, is proved as well by the reaction of the chloride of gold, as also by the appearances observed in inflammation, which *S. Stricker* has so carefully studied and illustrated.

Finally, my observations show that the living matter thoroughly traverses the fibrous basis-substance of the cornea in the form of an exquisitely delicate network, the existence of which is proved beyond all doubt by the correspondence of the negative silver with the positive gold pictures, though in the fresh condition of the cornea it is as imperceptible as the corneal corpuscles themselves. If wandering bodies exist within the normal cornea—I have never met with them—such bodies will find their paths only within the cement-substance, never within the lamellæ; and as the lamellæ are connected with each other by innumerable fine threads of living matter, which penetrate the cement-substance—not taking into consideration the connecting, broad, oblique bundles of fibres—the reason why such wandering bodies move in zigzag lines is readily comprehended.

As for the finer structure of the cornea, I fully agree with *C. Heitzmann's* views regarding the connective tissue in general. The living connection of the protoplasmic bodies, which this observer has discovered in the myxomatous and the fibrillar connective tissue, as well as in that of the cartilage and of the bone, has been successfully demonstrated by me on the cornea also. The living matter presents within connective tissue two different networks: a narrow one, the meshes of which are filled with fluid—protoplasm—and another with broader meshes, traversing the basis-substance.

EXPLANATION OF THE DRAWINGS.

FIG. 1. Lamella of the cornea of a cat, aged one year and a half, stained with a two-per-cent solution of nitrate of silver. Two layers. Immers. × 1000. *aa*, light fields with pale granular contents, with faintly marked nuclei, with coarse and fine processes, the latter radiating at *bb*. Every light field with perforated borders, and thus abundantly communicating with a delicate light network which traverses the whole dark-brown basis-substance in all directions.

FIG. 2. Lamella of the cornea of a cat, two years old, soaked in diluted lactic acid and then stained with a one-half-per-cent solution of chloride of gold. × 1000. *aa*, dark-violet fields—corneal corpuscles—the nuclei of which are mostly covered, with processes of different sizes. The structure of the corneal corpuscles is retiform, as the dark-violet granules are connected with one another by fine threads of the same color. The corneal corpuscles and their processes abundantly connected with a dark-violet network which traverses the pale-violet basis-substance (*bb*). The latter network shows broader meshes than that of the corpuscles and of their branches.

FIG. 3. Lamella of a cornea of a cat, two years old, stained with a one-half-per-cent solution of chloride of gold, after having been soaked with diluted lactic acid. Immers. × 1000. *aa*, dark-violet fields—corneal corpuscles—with only a few broad processes, but numerous dark-violet, thread-like connections—

non-medullated nerve-fibres (*bb*)—the latter partly traversing the corneal corpuscles, and partly joining the network of the same. Everywhere extremely fine retiform connections between the corneal corpuscles and the network of the basis-substance (*cc*) are present.

FIG. 4. Cornea of a cat, two years old, stained with nitrate of silver. Transverse section. × 1000. *aa*, light fields containing fine, pale granules, with coarse and fine light processes, the latter (*bb*) corresponding to nerve-fibres. The dark-brown basis-substance (*cc*) traversed throughout by a light network.

FIG. 5. Cornea of a cat, two years old, stained with a one-half-per-cent solution of chloride of gold, after being treated with diluted lactic acid. Transverse section. × 1000. *aa*, dark-violet fields, with broad branches and with fine processes, the latter (*bb*) nerves. The network of the dark fields everywhere in connection with that of the basis-substance (*cc*).

CONTRIBUTIONS TO THE KNOWLEDGE OF GLAUCOMA.

By Prof. Dr. J. SCHNABEL, in Innsbruck.

Translated by Dr. R. O. Born, of New York.

First Article.

Upon the anatomical examinations of glaucomatous eyes, thus far published, I have, in my paper on Glaucoma and Iridectomy (Vol. V., part 1, of these Archives), pronounced the opinion that we have not yet succeeded in proving the supposition that the clinical picture of glaucomatous ophthalmia is a consequence of a choroidal inflammation.

Herewith agrees the remark of *Hermann Schmidt*, published shortly after writing my article, that the name of choroiditis serosa does not explain the process of the acute glaucoma, and that the special accentuation of the choroiditis is quite incorrect, since ophthalmoscopical examinations and the pathological anatomy show that of all parts of the eye the choroid is least affected.*

Since then, *Sattler* has published some observations on cases of chronic inflammatory glaucoma.†

These entitle us, in the cases examined from the anatomical standpoint, to assume the condition of the choroid as inflammatory ; for in the capillary layer of the choroid, as well as in the more external unpigmented layer of fine elastic fibres, new cells in varying number could be demonstrated. But from the examinations we cannot derive a general conclusion in regard to the participation of the choroid in the glaucomatous process, since *Klebs* says that the inflammatory changes in the choriocapillaris, upon which *Dr. Sattler* places especial importance, are indubitable complications of the process; that they are absent in recent cases of simple glaucoma, as he knows from his own examinations of numerous bulbi which he obtained from *v. Graefe.*[*]

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* Handbuch der gesammten Augenheilkunde von *Graefe* u. *Saemisch*, V. 1, p. 102.

† Anzeiger d. K. K. Gesellschaft d. Aerzte in Wien, vom 9. December 1875.

The two latest publications on glaucoma are from *v. Wecker* and *Knies*. The former denies, as I do, the inflammatory character of the so-called inflammatory symptoms of the clinical picture;[†] the latter arrives at the conclusion that the glaucoma already, at a time when its diagnosis yet escapes the clinical examination, is prepared by an inflammation, and that also the so-called non-inflammatory glaucoma is only the result of an inflammation.[‡] But *Knies* found a distinct infiltration of the choroid only in the latter stages of glaucoma, where the globe was already secondarily softened, or where, while the tension was yet increased, the cellular infiltration extended into all the tissues of the eye. Therefore he holds that the cellular infiltration of the choroid can only with difficulty be regarded as the principal feature of glaucoma, and he places the original seat, in many instances the only place of the inflammation, in the neighborhood of *Schlemm's* canal. The necessary consequence of an indurating inflammation which culminates in this region is, after *Knies*, the obliteration of *Fontana's* space, and then the increase of the intraocular pressure. From the existence of the obliteration of *Fontana's* space, *Knies* thinks he can account for a series of other symptoms till now taken for the results of pressure. These are the corneal opacities, the anæsthesia of the cornea, the iridoplegia, the apparent shallowness of the anterior chamber, the paresis of accommodation, and the hyperæmia of the anterior scleral veins.

According to *Knies*, the nervous influence is "certainly of great importance" only for the origin of the glaucomatous attack (l. c., p. 196).

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[*] Prager medicinische Wochenschrift, 1876, No. 2, p. 45.

[†] *v. Wecker*, Glaucom und Augendrainage. Arch. f. Ophth. XXII., 4, p. 209.

[‡] *Knies*, Ueber das Glaucom. Arch. f. Ophth., XXII., 3, p. 163.

Following this view, the symptoms of glaucoma must—in analogy to *Donders*' theory—be traced back to two different sources: inflammation and anomalous innervation. But for the symptoms which *Donders* supposes to be a consequence of nervous disease, *Knies* claims an inflammatory origin, and the appearances in which, after *Donders*, the additional inflammation shows itself, *Knies* seems to refer to nervous irritation. I say "seems," for from *Knies*' article it is not evident enough to me how far the author attributes the clinical picture of glaucoma to abnormal innervation. *Knies* says the glaucomatous attack is the result of anomalous nervous action. But the attack is not a distinct complex of certain symptoms, it is much more the form in which each symptom of glaucoma or each combination of symptoms may appear. By the sudden rise and fall of the symptoms, by the form of the attack, the clinical picture of glaucoma receives an exceedingly characteristic appearance, and every attempt to explain the glaucomatous process must consider this peculiarity; but it must be well remembered that there is not one symptom of glaucoma which appears only in a form of an attack, and not one which could not appear in such a form. It has been perfectly settled and is probably established for every specialist, that every one of the symptoms referred by *Knies* to the inflammation in the neighborhood of *Schlemm's* canal appears also as an attack, and this is especially well known of the two most important of those symptoms, viz., increase of pressure and corneal opacity, because attacks of these symptoms can be frequently observed during the course of a case.

Now, if the slow and steady development and the constant continuation of the glaucomatous symptoms are due to the inflammation near *Schlemm's* canal, but the sudden attacks to anomalous nervous action, the necessary consequence is that there are two, in fact, perfectly different processes, either of which can create and maintain each symptom of glaucoma and each group of symptoms, and that further both processes can exist in the same eye simultaneously and alternate to present the clinical picture. In fact, what I laid down as a consequence of his doctrine, *Knies* pronounces distinctly in regard to the cardinal symptom of glaucoma, for he lets the pathological increase of pressure come from the obliteration of *Fontana's* space as well as from nervous influence (l. c., pp. 197 and 198).

It is therefore perfectly clear that the attempt to use *Knies*' theory for the clinical picture of glaucoma, which presumes that the neurotic theory is superfluous (l. c., p. 194), directly refers to the adoption of a primary neurotic nature of glaucoma; for although *Knies* ascribes only the "further" increase of pressure to nervous influence, we look in vain for an explanation why that agent should act only after the tension has already passed the normal, and why it should not also be able to produce the excess of tension.

When we try whether the view that the glaucomatous attack is caused by nervous influence is better adapted to the facts known; when we suppose that *Knies* by "attack" understands *Donders*' ophthalmia, we must first remark that among those symptoms which *Knies* refers to, the obliteration of *Fontana's* space, is also the corneal opacity, one of the most important symptoms of glaucomatous ophthalmia, and that there remains only pain and ciliary injection to prove the nervous irritation. Now these symptoms are frequent indeed, but not necessary for a glaucomatous attack, and we can observe the most exquisite attacks without any pain or ciliary injection. We are so much accustomed to connect with the name of acute glaucoma the idea of a so-called inflammatory glaucoma, that I do not fear it to be superfluous to refer here to the history of two cases of *acute, non-inflammatory* glaucoma.

Mrs. W., whose mother was taken ill with glaucoma some twenty years ago, is a very nervous, feeble lady, 36 years of age, who, as her family physician stated, suffers very frequently from the most horrible tonic and clonic convulsions. On June 7th, in the afternoon, when on the street, she suddenly became almost entirely blind. She hurried home, and the persons around her could not see anything else on the eye but "that a skin had grown over it." Also the family physician, when called, saw the opacity over the pupil. On June 8th, glaucoma was already diagnosticated and the operation proposed. On the 11th, I saw the patient the first time. I found the tension very much increased, the cornea characteristically dull, the anterior chamber and pupil normal, the vitreous unchanged, the papilla not excavated, the arteries nicely pulsating, the veins of the retina enormously filled and tortuous. Fingers could be counted only at a distance of 5 to 6 feet, the field of vision was contracted from the outer side. Pain and ciliary injection were entirely absent. Since there could be no doubt as to the diagnosis, an inward iridectomy was made on June 11th. The healing process and the effect of the operation left nothing to be wished for.

On June 14th, patient complained that the right eye, still closed by a protecting bandage, was slightly painful and, after removing the bandage, the cornea seemed to me not quite transparent. The pupil was of normal size and movable, the depth of the anterior chamber unchanged, the tension increased. The acuteness of vision could not be tested, but the patient believed that now also with her right eye she saw worse than before the bandage was applied. On June 17th, until 11 A.M., the patient saw well with the right eye; then her vision became dim, and this increased so much that at an examination, made at 1 P.M., she could count fingers only at a distance of a few feet. Directly in front and toward the temporal side, the patient did not see at all, and the fingers could be counted only toward the periphery of the inner half of the visual field. The cornea was as opaque as I had seen it in the left eye before the iridectomy *The anterior chamber had become shallower.* The pupil was of normal width and reacted promptly to the light. The vitreous, seen by the ophthalmoscope, appeared unchanged. The papilla was reddened, the central artery pulsated distinctly, the veins were strongly filled. The hardness of the eyeball was very great. There was no pain at all. On June 18th, also in the right eye an inward iridectomy was made. On that day, I found the chamber still shallower than on the day before. The other symptoms were unchanged. The effect of the operation was perfect. At the end of the year 1876, I saw the patient again; the colobomas were the only visible consequence of her disease.

2. *Peter H.*, 76 years old, a yet tolerably vigorous man, who lost the sight of his left eye by glaucoma more than ten years ago, was reading his newspaper on February 11th, 1876, at 10½ P.M., and went to bed on account of a slight uneasiness, combined with a chilly feeling. When

he awoke after a well-passed night, he was almost entirely blind. The window appeared to him as a light spot, and he endeavored in vain to recognize the largest objects. Before this disastrous morning, the careful and reliable patient (who was still working as a tailor) had not the least cause to complain of his right eye. During the following day his condition remained unchanged. He experienced no pain, and only after repeated inquiries he was compelled to state that he had noticed some heaviness in his head. The next night was quiet, and on the morning of the 13th, he could distinguish the window-frame from the lighter glasses. On the evening of the 13th, he was transferred to *v. Jaeger's* ophthalmic wards. At an examination made immediately, *Dr. Herzendorfer* found the cornea quite opaque with perfectly good reflection, the size of the pupil normal, the intraocular pressure much increased, the acuteness of vision reduced to quantitative perception of light. In the morning of the 14th, the patient could see again ; in this state I examined him the first time. The tension was but little above the normal ; with — $\frac{1}{30}$ S. = $\frac{20}{100}$, with + $\frac{1}{8}$, he read No. 3 ; the field of vision normal. The cornea perfectly transparent and reflecting ; the conjunctiva bulbi very little injected, the lower conjunctival fold slightly œdematous, the iris of normal color, the pupil of normal size, the anterior chamber of normal depth, the lens strongly reflecting, but the images of the mirror well seen ; numerous small, fixed opacities containing cholesterine in the vitreous, rendering the inspection of the papilla difficult. The latter is reddened, the veins strikingly large, the arteries relatively small. No trace of an excavation.

On the 15th at noon, the patient again became suddenly so blind that he could not see the persons around him. This blindness continued for an hour. Shortly after it had ceased, I found the bulbus very hard, the size of the pupil and the depth of the anterior chamber normal ; the cornea reflecting, and in its centre a grayish, sharply defined opacity of rhomboidal shape. Of the fundus I could only see here and there a piece of a vessel, S. = $\frac{20}{200}$. Pain was entirely absent. On the morning of the 16th, an inward iridectomy was performed. Course of operation and healing, as well as the effect of the operation, were good. An excavation was not formed.

[Although there is no immediate connection, I may yet be permitted to mention here a case in which I observed the outbreak of acute glaucoma after atropine-instillation. It is hardly necessary to give new evidence of the real existence of a casual connection between the instillation of atropine and the glaucomatous attack. But my observation may deserve to be specially mentioned, because it contains one feature which distinguishes it from all the other similar observations hitherto known, and which might later be of some importance for an explanation of that remarkable influence of the atropine.

Moritz P., 60 years old, was admitted to *v. Jaeger's* clinic on February 8th, 1876, for glaucoma o. d. The eyeball was extremely hard, the cornea so opaque that of the fundus nothing could be seen, the pupil of medium size, immovable. Pain absent. Fingers counted at 6′. Considerable limitation of visual field inward.

The left eye showed no other anomaly, but a dirty, grayish-green discoloration of the optic disc. The desire to examine this nerve accurately, led me to instil a solution of atropine of 1 : 2,500 to dilate the too narrow pupil. This was done on Feb. 8th, at 4 P.M. About three hours later, after the pupil had slowly and moderately dilated, the patient felt bad, had pain in the head and around the left eye, and lost the sight in it. When I saw him again the next morning, about 19 hours after the instillation of the weak solution of atropine, he complained that he had not slept during the night, had vomitted five times, and that the left eye was very dim. The left cornea was now like the right; the fundus could not be seen. The depth of the anterior chamber was not changed by the glaucomatous attack. The tension abnormally great. Twenty-four hours after the instillation, the pupil had again become considerably narrower. Forty-two hours after the atropine had been used, the iridectomy was made, since the eye had already a distinct glaucomatous habitus, and his sight had been reduced to the counting of fingers at 8′.]

Now, this is the report of three eyes in which acute glaucoma caused only such symptoms as *Knies* derives from the obliteration of *Fontana's* space, *i. e.*, increase of tension with its consequences, corneal opacity, and shallowness of the anterior chamber. The attempt to apply *Knies*' theory to these cases brings this theory into indissoluble contradictions with itself.

Before I proceed to the discussion of the anatomical changes upon which *Knies* bases his theory, it seems necessary to me to settle what is meant by the somewhat indifferent term: "Inflammation in the neighborhood of *Schlemm's* canal" and "Obliteration of *Fontana's* space."

It is known that *Schlemm's* canal is situated very near the corneal margin, between the two surfaces of the sclerotic. It is, however, not imbedded in the scleral tissue itself, but takes its course in a channel-like excavation of the posterior scleral surface which lies between the margin of Descemet's membrane and the ciliary muscle, and is filled chiefly by a number of sieve-like perforated lamellæ which are placed above each other.

Schwalbe says that *Schlemm's* canal is formed simply by the scleral channel being covered by those lamellæ, and that the bottom of the channel becomes the anterior wall of *Schlemm's* canal.* This picture explains the relations of the parts admirably; it could, however, as *Waldeyer* remarks, easily lead to the wrong idea of two different tissues composing the canalis Schlemmii.† In accordance with *Waldeyer*, I find that also the anterior wall of *Schlemm's* canal is not directly formed by the sclerotic, but by a thin layer of the same cavernous tissue which separates the canal from the anterior chamber. In meridional cuts of the sclero-cornea, the canal has generally the form of a transverse section of a lens. It presents a fissure which gapes mostly in the middle, which with one point reaches not fully the margin of Descemet's membrane, and with the other extends very little farther towards the equator than the insertion of the ciliary muscle on the sclera. Hence, it has only an anterior and a posterior wall, and is surrounded on all sides by the tissue filling the scleral channel. The latter is a portion of that peculiar lamellated and columnar tissue which fills the space between the margin of Descemet's membrane, ciliary muscle, and insertion of iris on one side, and the sclero-cornea and ligamentum pectinatum iridis on the other, and which corresponds to the region of the ox's eye described by *Fontana* as a new canal of the eye. Again, *Fontana's* canal as an annular cavity with definite walls we now know is only artificially produced by the mechanical destruction of the loose columnar tissue, the numerous communicating cavernæ inclosed between the columns being united.* It is therefore more correct to speak of *Fontana's* space, understanding by this name the whole region, including its columnæ and cavities. If we accept this term, then we must also in the human eye speak of a *Fontana's* space. Within it lies *Schlemm's* canal, and whatever is said about the surroundings of this canal means the tissue of *Fontana's* space. *Knies*, however, adheres to another view, since he differentiates between *Fontana's* space and the parts around *Schlemm's* canal. Thus, in a description of a case, he says that the neighborhood of Schlemm's canal was pervaded by cells (l. c., p. 167), while *Fontana's* space was yet well preserved and normal throughout (l. c., p. 194). Furthermore, he assumes that *Fontana's* space is a cavity, since he speaks of its obliteration. Some authors, however, though rejecting the hypothesis of *Fontana*, yet mean a cavity when speaking of *Fontana's* space. They call so the cavernæ between that peculiar loose columnar tissue before mentioned, and consequently speak of *Fontana's* spaces.† In the human eye, however, larger spaces in this columnar tissue do not regularly occur, and "generally man has no *Fontana's* spaces" (Waldeyer, l. c., p. 229).

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* *Schwalbe*, Untersuchungen über die Lymphbahnen des Auges und ihre Begrenzungen. *Schultze's* Archiv f. microscop. Anatomie, VI., p. 301.

† Handbuch der ges. Augenheilkunde von *Graefe* und *Saemisch*, I., p. 229.

Knies, who calls *Fontana's* space a cavity with definite walls existing in every human eye, who, in order to demonstrate that already *Heinrich Müller* had known the obliteration of *Fontana's* space, refers to a passage where that author speaks of an agglutination of the walls of the anterior chamber, apparently denotes by that name the peripheral parts of the anterior chamber.

It is a maxim which facilitates essentially clearness, not to use a customary name in a sense fundamentally different from the one generally applied. Therefore, I shall, in the following remarks, instead inflammation in the neighborhood of Schlemm's canal, which causes the obliteration of *Fontana's* space, say, inflammation of the columnar tissue of *Fontana's* space, which leads to the obliteration of the sinus inclosed by the most peripheral parts of the walls of the anterior chamber.

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* *Iwanoff* und *Rollett*, Bemerkungen zur Anatomie der Irisanheftung und des Annulus ciliaris, Arch. f. Ophth., XV., 1, p. 51.

† Handbuch d. ges. Augenheilkunde von *Graefe* und *Saemisch*, I. Abbildung auf p. 266.

If we imagine a cylinder erected in a normal eye, on the basis of a plane passing through the margin of Descemet's membrane, and its circumference coinciding with that margin, and if we suppose the surface of the cylinder to extend posteriorly to the plane of the iris, there remains between the surface of the cylinder and the lateral wall of the chamber an annular space, which is limited behind by the iris, in front by the ligamentum pectinatum. This space, as has been often noted, is generally missing in glaucomatous eyes; here the periphery of the anterior chamber coincides with the margin of Descemet's membrane, or it is even smaller than the circumference of that membrane. The anterior and posterior wall of the anterior chamber meet directly; its lateral wall disappears. The sinus of the chamber is replaced by a real margin of the chamber. *Schlemm's* canal which, in meridional sections of normal eyes, lies opposite the lumen of the chamber in its whole length, is in the glaucomatous eye posterior to the margin of the chamber, even with its corneal end. Only a short time ago this change of form of the anterior chamber was explained by the opinion that, by pathological increase of intraocular tension, the iris was pressed against the anterior wall of the chamber.* Thus it was, analogous to the displacement of the lamina cribrosa, taken for a change of position caused by the anomaly of pressure, and no consequence was ascribed to it in regard to the further course of the process and the formation of the clinical picture of glaucoma. Not the knowledge of the changes, constantly found by *Knies*, but their interpretation is new, and only to the latter refer the following considerations. Their object is to decide:

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* *H. Pagenstecher*, Ueber Erweiterung des sog. *Petit*'schen Canals, etc. Arch. f. Ophth., XXII., 2, p. 292.

1. Whether the obliteration of the sinus of the chamber is characteristic of glaucoma, and only found in this disease.
2. Whether the infiltration of the columnar tissue in *Fontana's* space is peculiar to glaucoma.
3. Whether this infiltration has to be regarded as the result of an inflammation of this tissue.
4. Whether the obliteration of the sinus of the chamber has to be looked upon as a consequence of this inflammation, or how else it does take place.
5. Whether it is necessary that glaucomatous symptoms follow the infiltration of the columnar tissue of *Fontana's* space and the obliteration of the sinus of the anterior chamber.

I.

The agglutination of the surface of the iris to the opposite anterior wall of the chamber in its most peripheral portions I have constantly found in all those eyes examined by me, in which the iris had healed into a perforating wound of the cornea. The age of the individual and the refraction of the affected eye did not influence that agglutination. It is also indifferent for its formation, whether the corneal cicatrix is large or small, central or marginal; whether the cornea, resp. the new-formed cicatricial tissue, has retained its normal curvature, or whether it has become bulged or flattened; whether the corneal circumference remained normal, grew larger or smaller, and, finally, whether the intraocular tension is increased, normal, or decreased. In those cases where the entire pupillary margin, or a circle of iris concentric to it, was held in the corneal cicatrix, I found also the surface of the iris in its whole circumference attached to the ligamentum pectinatum. But when only a portion of the pupillary margin, or of a concentric circle of the iris, had healed in the cornea, there was also only the peripheral portion of iris, corresponding to the anterior synechia, agglutinated to the cornea. Generally the adherence to the walls of the chamber extended to the margin of Descemet's membrane; sometimes it did not reach it, in some cases it extended beyond it, and I found a circle of the membrana Descemetii 1 to 2 mm. broad, in contact with the corresponding surface of the iris. Between the two agglutinated walls of the chamber I have never seen any pathological, new-formed tissue; also after separating the pathological adherence, I could never observe a tissue which did not belong to the normal constituent parts of the iris or the ligamentum pectinatum.

The adhesion showed different degrees of firmness.

The attempt to separate the sclero-cornea from the choroidea-iris never showed a clean smooth surface of the formerly united tissues. To the iris always adhered some columns of the ligamentum pectinatum, to the latter cells of the iris-tissue. Before the connection was perfectly interrupted, I saw between the two agglutinated surfaces bands of the ligamentum pectinatum, covered with cells of the iris, extend as a variously formed bridge. Sometimes I saw Descemet's membrane detached from the cornea and remaining connected with the iris. In two eyes, in which the obliteration of the sinus of the chamber was circular and the iridectomy had been made, I found the adherence except in the part corresponding to the coloboma. This was not effected by the knife, for the inner wound was in Descemet's membrane, and the attachment had only extended to its margin. The traction on the iris at its exsection had loosened the abnormal connection. This traction was in one case (1, *a*), certainly not forcible, as was shown by the position of the processus and the stump of iris; in the second case (2), the processus were pulled considerably toward the axis of the eye, and a strong traction must have been exerted. Another circumstance, however, in this case demonstrated that it did not require a great effort to separate the connection between cornea and iris, since it was also loosened by an extravasation into the anterior chamber.

The columns of the fenestrated lamellæ, which bridge over the scleral channel, showed frequently a perfectly normal condition. Sometimes the lamellæ were pressed together so much that I missed the spaces between them. Between the lamellæ and their meshes, up to the walls of Schlemm's canal, I found frequently pigment in single granules, or in irregular heaps of varying form and size, or imbedded in cells of the character of lymphoid corpuscles. Also white and red blood-corpuscles in varying number were sometimes found in the columnar tissue of the scleral channel, between its lamellæ up to the margin of Descemet's membrane and between the columns into which it blends, at the origin and the inner surface of the ciliary muscle.

Schlemm's canal showed in meridional sections mostly the normal form of a fissure, and nothing was found between the endothelial coverings of its walls. Sometimes its lumen was narrowed or even perfectly destroyed.

The piece of iris which was attached showed in some cases normal texture and density, in others it was pervaded by pus and blood-corpuscles, in others free from inflammatory products, but very much thinned, leaving only the pigmentary layer of the posterior surface. The thickness of the corresponding piece of iris was sometimes normal, and its anterior surface simply joined closely the inner and anterior wall, following its curvature; sometimes the origin of the iris was found thicker than normal, but loosened, the spongy iris attached at its surface and sinking by its gravity, apparently stretched from in front backwards. The surface presented in these cases a wave-like appearance with pointed projections. Sometimes the origin of the iris was enormously thinned and transformed into a thin sheet.

The sclerotica around the scleral channel, as well as the ciliary body, showed no changes which could not have been brought in direct connection with the adhesion of the walls of the chamber.

1. *Alois Brandeker*, 26 years of age, was treated in *v. Jaeger's* clinic, from October 24th, 1871, to March 12th, 1872, for a gonorrhœal ophthalmia of both eyes, which brought on extensive ulceration of both

corneæ, with perforation and prolapse of iris. On May 4th, a *superficial* central leucoma with indistinct margins and extensive adhesion of iris was ascertained in the *right* eye. The pupil was not visible. Fingers were counted at 1½′. In the *left* eye the cicatrix was at that time *bulging*, the iris around it adherent. Outwards a space of cornea, a little more than 1‴ in breadth, remained transparent, in all other directions it was only a little over ½.‴ On May 6th, 1872, an inward iridectomy was made in the left eye. The healing process was perfectly normal, and the patient could leave the hospital by May 10th. He then counted fingers at 5′.

On April 23d, 1874, *Brandeker* died of pulmonary tuberculosis, and I enucleated the eyes nine hours after his death.

a. Right globe. Length of axis 21.3 mm., horizontal diameter 20.7 mm., vertical diameter 21 mm., diameter of cornea 10.5 mm. The immense cicatricial opacity of the cornea is nearly round, is about 6 mm. in diameter, and lies in the level of the normal cornea. The iris corresponding to this cicatrix attached to the posterior corneal surface. The space of the cicatrix is, from within, cup-like, and corresponding to the excavation thinned to one-half of the normal thickness of the cornea. The uveal pigment appears normal. With the magnifying glass nothing abnormal can be seen on the ciliary processes. The cicatrix of the iridectomy I could not detect on the outside, not even with the magnifying glass. Next to the processus the coloboma measures 4½ mm., and in its opening are 15 ciliary processes which are entirely like their neighbors. The ligamentum pectinatum is in its whole length attached to the surface of the iris. Only at the site of the coloboma they are not grown together. The optic nerve is not excavated.

Microscopical Examination.—There is no space between anterior surface of iris and ligamentum pectinatum. Only at the coloboma exists a small sinus between the stump of the iris and the anterior wall of the chamber; but here distinct traces of a former agglutination of both surfaces are present. In the first place, the concave inner side of the sinus of the chamber is everywhere yet connected with the tissue of the iris; further, frequently point-like projections of iris rise above the anterior surface of the stump, the points of which are directed toward the ligamentum pectinatum; finally the latter itself is throughout covered with remainders of iris-tissue. The agglutination extends nearly to the margin of Descemet's membrane, and is not effected by an interposed substance. At its attachment, the iris is thicker than normal. This condition is not the result of real increase in volume, but of stretching, as can be seen from the different direction of the pigmented cells in that portion, its long processes being directed toward the cornea, resp. the posterior surface of the cornea. Very near the end of the ligamentum pectinatum, the anterior plane of the iris sinks into the normal level, thereby forming a point in the profile of the section of the iris, which is adherent to the cornea. From this point toward the centre of the cornea—gradually more and more scanty—pigmented cells of iris are found. All possible forms of connection between iris and ligamentum pectinatum are seen in the different preparations. There is not in all of them a joining of the surfaces; in many we observe columnæ of the ligamentum pectinatum either with or without iris-cells, approaching the iris in an oblique direction and uniting with it. In these cases, manifestly, the adhesion has been too weak to retain the iris permanently in that unnatural position. Very similar preparations can be obtained by slightly separating the iris from the cornea in meridional sections, in which a perfect adhesion of the surfaces exists. Neither the iris nor any part contributing to the formation of the periphery of the chamber show imbedded cells. The lamellæ which overhang the canalis Schlemmii and its columns are perfectly normal. Schlemm's canal everywhere gaping and emptied, presenting generally a simple split pointed on both ends; in meridional sections the ends are rarely dilated into sinuses or are bifurcated. Sometimes the aperture of Schlemm's canal is by bridges divided into three to four oblong openings.

b. Left bulbus. The ectasia of the corneal cicatrix, which was observed on the living at an examination on May 4th, 1872, could no longer be detected in the dead eye. The proportions in the eyeball were the same as in the right. The margin of corneal tissue preserved was smaller than in the right. In the section, the distance of the base of the iris from the nearest point of attachment was 2.640 mm. The iris is adherent, not only to the ligamentum pectinatum, but also to a small circle of Descemet's membrane. Where the membrana Descemetii begins to be separated into the lamellæ, there is a notch in the posterior surface of the cornea into which the iris is pulled, and there retained in the form of a pointed elevation. The insertion of the iris is thinned. The thinning is mostly marked at the insertion, and disappears gradually toward the free margin. Meridional sections of the iris have consequently a triangular form with the obtuse point at the ciliary body. In some meridional sections only the uveal layer of the iris is preserved. In preparations in which the iris has been separated from the cornea, the columns of the ligamentum pectinatum remain connected with the iris, and extend obliquely from the cornea to the iris, blending together with its anterior surface. The lamellæ at the scleral margin are pressed closely together. Between them lie numerous small heaps of pigment. An open canalis Schlemmii is wanting almost throughout; only in a few meridional sections there are two or three small openings in the situation of Schlemm's canal. Neither in the columns of Fontana's space, nor in the iris, or in the ciliary body, or in the sclerocornea, is there a trace of cellular infiltration. The level of the optic disc is normal.

2. *Joseph Peibel*, 56 years old, lost the sight of the right eye in consequence of an inflammation in November, 1873. On October 17th, 1874, a white cicatrix was visible in the lower half of the cornea, which extended into the pupillary space. The lower portion of the iris was adherent to the cicatrix. The pupil, irregular by numerous posterior synechiæ, was dilated very little by atropine. The lens cataractous, and attached to the iris and cornea. The tension of the eyeball below normal, sight reduced to quantitative perception of light. External signs of a preceding inflammation were entirely missing. The left eye showed no abnormity, neither by external nor by ophthalmoscopic examination; S. $=\frac{20}{50}$.

On October 24th, 1874, an inward and upward iridectomy was made in the right eye. October 26th: pain in the operated eye, effusion of blood into the anterior chamber. October 27th: pain has disappeared. October 30th: the blood in chamber unchanged; the wound closed. October 31st: patient died at 4½ P.M. The autopsy showed chronic Bright's disease with eccentric hypertrophy of the heart, œdema of the brain and lungs.

The anatomical examination of the eye showed the pupil perfectly closed by a membrane, which was attached to the lens as well as to the corneal cicatrix. One-fourth of the iris was cut out. In some meridional sections the iris appeared attached to the ligamentum pectinatum up to the margin of Descemet's membrane. In some sections the anterior surface of the iris had an eminence which was imbedded and retained in a depression at the margin of Descemet's membrane. Outwards from this point of attachment the iris was again either perfectly free, or single threads extended from the ligamentum pectinatum to the anterior surface of the iris. Some sections showed the iris closely joined and attached only to the inner wall of the chamber, but the part of the ligamentum pectinatum next to the corneo-sclera did not adhere to the iris. In these sections the iris had approached the cornea to such an extent that the anterior surface of its insertion was situated in the same plane with the scleral surface of the ciliary muscle, and opposite the margin of Descemet's membrane was a pointed eminence in the profile of the iris, which, however, did not reach the cornea. No attachment between stump of iris and ligamentum pectinatum; the former drawn far away toward the axis of the eye. Red blood-corpuscles in considerable quantities were lying between the layers of the ligamentum pectinatum, between the single fascicles of the tendon of the tensor, between the columns of *Fontana's* space, on the anterior surface of the iris, and in the tissue of its insertion, and also in that of the ciliary muscle. The weight of the blood then had partially loosened the circular attachment of the iris and the ligamentum pectinatum which had manifestly existed before. In most of the sections *Schlemm's* canal was gaping and emptied. In many I found isolated blood-corpuscles in it, and in some it was even densely filled with red blood-globules. None of the tissues comprising the angle of the iris had undergone a purulent infiltration. The level of the optic disc was normal.

3. *Johann Pemsel*, 25 years of age. The right eye was enucleated during life on November 4th, 1873; the left on April 22d, 1874, after death. The latter was perfectly normal. The clinical history of the former remained unfortunately unknown to me.

The size and form of the right eyeball do not differ from the normal. The cornea has a horizontal diameter of 10 mm., and has in its centre a very dense, white, disciform cicatrix of more than 5 mm. diameter in its normal level. The thickness of the cicatrix is 3 mm. in the centre. The cornea around the cicatrix appears normal. The pupil is irregularly oval, perfectly adherent to the corneal cicatrix, which from behind through the pupil looks as white as chalk. The iris presents nothing striking on its posterior surface; the radiation, the pigmentary layer are the same as in the normal eye. There exists, then, an attachment of the anterior surface of the iris around the pupil to the posterior surface of the corneal cicatrix, and to the circle of normal cornea corresponds also a circular chamber around the immense synechia. The processus ciliares normal in situation and form. The lens in normal position, with a depression of its anterior surface at the pupillary space. In meridional sections the iris was again seen agglutinated to the ligamentum pectinatum. In several sections the attachment does not reach the margin of Descemet's membrane; in not one does it extend beyond it. The insertion of the iris is perfectly normal in thickness and structure and not at all stretched. It forms an arch convex in front in meridional sections, since its anterior surface joins the inner and anterior wall of the chamber. The connection is loose. In many sections the iris is depressed, and the ligamentum pectinatum and the separated posterior lamellæ of *Fontana's* space are interposed between the main portion of the cavernous tissue and the iris. The cavernous tissue is perfectly normal. In some places the sheaths of endothelium are detached from the columnæ, and between them we see plates of epithelium in manifold forms. The canalis Schlemmii has not the form of a fissure. In its place are three to four round, or elliptical small lumina.

No infiltration of the tissue forming the periphery of the chamber. Level of papilla normal. In the left eye the sinus of the chamber has a normal appearance throughout.

4. *Franz R.*, 44 years old ; died on April 12th, 1874.

Twenty-nine hours after death, I enucleated both eyes. The right showed no anomalies. In the left eye. out- and downward, about midway between centre and circumference of the cornea, was a very small corneal cicatrix, towards which the pupil was drawn. Having cut the bulbus in the equator and removed the vitreous and lens from the anterior half of the eye, I saw the iris normal with exception of the pupil. The latter had the form of a drop, the point of which stood off only a little farther from the centre of the cornea than would have corresponded to the place of the pupillary margin in the normal eye. The pupillary margin was entirely free, only a piece of the iris between its insertion and the free margin had entered the anterior synechia. In meridional sections a cup-like depression of the inner surface was observed corresponding to the corneal opacity, and at its margin Descemet's membrane was interrupted and filled with rarefied tissue of the iris. In many sections the defect of Descemet's membrane extended so far toward the circumference of the cornea that the distance between the (not dislocated) ciliary muscle and the boundaries of the defect of Descemet's membrane was only 2.310 mm. The piece of iris between these two points was nearly throughout attached to the ligamentum pectinatum, resp. Descemet's membrane. In some places the iris lay close to the anterior wall of the chamber beyond Descemet's membrane, then receded from it, and again approached Descemet's membrane 1 mm. from the anterior synechia and from there remained firmly adherent. The insertion of the iris was stretched, considerably thinned, in some places reduced to the uveal layer.

The cavernous tissue of *Fontana's* space was compressed, and sometimes its openings could not be seen at all. Schlemm's canal formed a very small split, or was made entirely invisible by compression. A good deal of pigment in granules and small heaps in *Fontana's* space, mostly accumulated near the posterior wall of Schlemm's canal. No infiltration of cells in any of the tissues forming the angle of the iris. Level of papilla normal. Very interesting indeed was the condition of the sinus of the chamber in sections made through parts of the anterior half of the bulbus, in which the iris had not entered the anterior synechia. In many sections the proportions of the sinus of the chamber were almost normal; but in most of them the sinus had shrunken by an elevation of the insertion of the iris, thus approaching the surface of the cornea, without, however, touching it. But the lateral wall of the chamber was adherent to the surface of the iris. The contents of *Fontana's* space had their normal size. The single columns with their nuclei were again distinctly visible. No pigment was found between them and the canalis. Schlemm's canal was normal in breadth, gaping and empty.

The optic nerve was normal.

The anatomical relations of the angle of the iris were perfectly normal in the right eye.

5. *Peter Linzerboth*, 66 years old, came to *v. Jaeger's* clinic on June 16th, 1876, on account of a total cicatricial staphyloma of the right cornea, which had the form of a cylinder. It had existed for two years, and prevented him from closing the lids. No signs of irritation. Tension glaucomatous.

On June 19th the globe was enucleated. The measurements immediately after the operation were: axis, from top of staphyloma to posterior pole, 28.5 to 28.8 mm.; elevation of staphyloma, 7–7½ mm.; base of staphyloma, resp. cornea, 11 mm.; diameter of the staphylomatous cylinder in the middle of its height, 11 mm.; transverse diameter of the eyeball, 22.5 mm.; vertical diameter, 22.2 mm. On December 8th, 1876, I found the bulbus, which had up to that time been preserved in Müller's fluid, unchanged in form. The distance from top of staphyloma to posterior pole, 28.75 mm.; from posterior pole to posterior surface of lens, 17 mm.; thickness of lens, 3.75 mm.; distance from anterior surface of lens to top of inner wall of staphyloma, 6 mm.; wall of staphyloma, at its summit, 2 mm.; the diameter of the circle, inclosed by the ridges of the ciliary processes, 12 mm.

The lens was in its normal plane, notwithstanding the increased intraocular pressure which had produced a deep, total excavation of the optic disc. The zonula, in its free portion, was more tightly stretched and somewhat longer than normal. The iris everywhere joined closely the wall of the staphyloma, so as to form a part of it. The insertion of the iris was very much thinned, and attached all around to the ligamentum pectinatum and the membrana Descemetii. Towards the corneal centre the attachment extended 2.640–2.970 mm. beyond the margin of Descemet's membrane. Most firmly adherent were iris and ligamentum pectinatum. In this part almost only the uveal tissue of the iris remained. The cavernous tissue of Fontana's space was well preserved, but very much compressed. Considerable accumulation of pigment between the columns, especially around Schlemm's canal. The lumen of the latter was reduced to a small slit, in which, in some sections, I could see a few red blood-corpuscles. Where the iris had been separated from Descemet's membrane I could most distinctly see that there was no substance between them. Only in the connective tissue of the ciliary muscle, round cells in small quantity were found. The cavernous tissue between the margin of Descemet's membrane and the ciliary muscle was enormously stretched. The ligaments ran (in meridional sections) in a straight line toward the muscle. Also the meridional bundles of the ciliary muscle were noticeably stretched. The circular fibres were very scarce.

6. *Anna Z.*, 7 years of age. The left globe was enucleated on July 10th, 1875, on account of a corneal staphyloma, preventing the closure of the lids.

The measurements immediately after the operation showed: axis, from top of staphyloma to posterior pole, 31 mm.; horizontal and vertical diameters of the eyeball, each 23 mm.; the elevation of the staphyloma, 12 mm.; thus, the distance from the posterior pole to the base of the cornea, 19 mm. The staphyloma had a thin, transparent wall, presenting a vesicle filled with fluid. Upwards a margin of normal cornea, 3 mm. in breadth, remained; at all other sides the cornea was replaced by cicatricial tissue up to the scleral junction. The lens was in its normal plane. Corresponding to the preserved portion of the cornea, I found also the iris intact; but the central margin of this piece of iris was agglutinated to the border between cornea and cicatrix, which was marked by a deep depression, and in its whole breadth it was pressed against the cornea. Corresponding to the bulging cicatrix, the iris was reduced to single columns, which formed dark ridges on the inner wall of the staphyloma.

The iris, considerably attenuated, was everywhere adherent to the ligamentum pectinatum. On attempting to separate the connection, columns of the ligamentum pectinatum followed the iris, and even Descemet's membrane was separated from the cornea together with the iris. The cavernous tissue of Fontana's space was strongly compressed; the lumen of Schlemm's canal absent. Its position was marked by heaps of pigment. Only in the connective tissue of the ciliary muscle here and there round cells. Shallow physiological excavation.

I omit on purpose the description of further examinations of glaucomatous eyes, since they are not able to teach more than those alluded to. I have examined very many eyes with bulging corneal cicatrices, and in all of them found the sinus of the chamber obliterated in the above-described manner. My experience entitles me to suppose that these relations are found in corneal staphylomata without exception. I will not leave unmentioned that we must distinguish between the attachment of which I spoke before and the connection of the remaining iris and cicatrix after destruction of Descemet's membrane. This kind of attachment does not concern us here at all.

2.

The infiltration of the cavernous tissue of Fontana's space with red and white blood-corpuscles, with pigmented cells, pigment molecules, and heaps, I have observed in hemorrhage into the anterior chamber; in iritis without simultaneous disease of the corneo-sclera; in keratitis ulcerosa, where the iris participated in the inflammation to a variable extent, with or without collection of pus in the anterior chamber, before or after the perforation of the ulcer; in complicated inflammations of the anterior segments of the eyeball, with and without hypopyon, as they occur after injuries. An infiltration confined only to the tissue of the scleral channel (neighborhood of Schlemm's canal) or so predominating at this part that it could have been looked upon as the starting-point of the disease, I have never seen yet. I have also never observed that the infiltration of the tissue of the scleral channel had extended beyond it into the sclera. In stained meridional sections through the corneo-scleral margin of such eyes in which the cavernous tissue of Fontana's space is densely infiltrated, the strongly colored contents of the scleral channel contrast very nicely with the normal appearance of the sclerotic.

The cavernous tissue is sometimes so densely infiltrated that its spaces are entirely filled. The infiltration is most clearly seen in surface-preparations, made in the following manner: On a sector of the anterior half of the eye we separate the chorioidea-iris from the sclero-cornea. The columnar tissue, which, as long as the iris is in it, descends along the inner side of the ciliary muscle and loses itself partly in this, partly in the iris, remains in contact with the sclero-cornea, and appears as an elevation concentric with Descemet's membrane. If we take this up with a pair of forceps and draw it from its foundation toward the corneal centre, we find it connected with the ligamentum pectinatum and the tissue covering the scleral channel up to the margin of Descemet's membrane, and even with a portion of it. If we now put the object under the microscope with the side looking to the chamber placed upward, we see the infiltration nicely ; but still better if with needles and forceps we split the preparation into single lamellæ. In some cases the infiltration assists in demonstrating the lamellar arrangement of the tissue between the margin of Descemet's membrane and the ciliary muscle. In meridional sections we can thus observe that between every two lamellæ a layer of pus and blood-corpuscles is interposed. The lamellæ themselves I have never found to be destroyed or even essentially changed. In surface-preparations I could see the nuclei of the epithelial sheaths covering the trabeculæ in a normal distribution, number, and size.

The canalis Schlemmii showed always some anomalies. Most rarely I found anomalies of its contents, as pus or blood globules isolated or even perfectly filling its lumen. Generally its form was changed, being narrowed in its whole length and even entirely obliterated, and the walls pressed together. I noticed that its two walls were not in the whole length approximated to touch each other, but only in some places, and that the canal was thus divided by isthmuses into two or more small lumina.

In none of the cases in which I saw Fontana's space infiltrated, the iris and ciliary body were in a normal condition, they always showed a similar infiltration. The sinus of the chamber sometimes contained blood, sometimes pus, in some cases it had no abnormal contents. The conformation of the sinus was sometimes normal, sometimes abnormal by conditions independent of the infiltration of its walls.

7. *Karl Tollich*, 66 years old, was admitted to *v. Jaeger's* clinic on August 26th, 1876, with iritis specifica o.d., and died on December 26th, 1876, of a left-sided pneumonia, rapidly terminating the life of the patient who was very much reduced by a chronic Bright's disease.

Tollich's eyes had been inflamed for two months before he came to the hospital, and when he entered he had no more signs of a recent inflammation. In both there were numerous posterior synechiæ and pupillary exudation ; the chambers had the normal depth. The acuteness of vision in the right eye was $\frac{5}{200}$, in the left only quantitative perception of light. Tension in both changing, but never abnormally increased and mostly below the normal.

The microscopical examination of the anterior segment of the right eye showed: corneo-sclera perfectly normal; iris in its whole mass and extent densely infiltrated with pus-corpuscles, in the same manner the ciliary body. No abnormal contents in the anterior chamber; only in its extremest periphery, partly upon the ligamentum pectinatum, partly upon the anterior surface of the iris, lie some isolated pus-corpuscles. The cavernous tissue in the angle of the iris, from the iris to the margin of Descemet's membrane, and from Schlemm's canal to the ligamentum pectinatum, densely infiltrated with pus-cells. The canalis Schlemmii in some meridional sections narrowed and containing some pus-corpuscles, in other sections in two or three small apertures, in others again its lumen entirely abolished. The form of the sinus of the iris is almost everywhere normal; in some places, by swelling of its peripheral portion, the anterior surface of the iris has approached the cornea. A contact of the anterior and posterior walls of the chamber nowhere exists.

8. *Joseph Popowsky*, age 20 years, came to *v. Jaeger's* clinic on April 6th, 1875, on account of a keratitis pustulosa of both eyes, and died of tuberculosis on April 27th, 1875.

a. Left eye. In the upper half of the cornea, nearly reaching its margin, a sharply-defined elliptical ulcer, which measures in its longest diameter 5½ mm. The bottom of the ulcer is very thin. The cornea around the ulcer thickly pervaded by pus-corpuscles. The sclera normal. The form of the sinus of the chamber normal. In meridional sections the cavities of the tissue in Fontana's space come out clearly. Within it a scanty purulent infiltration which disappears toward Schlemm's canal. The latter has mostly the form of a fissure, is gaping and empty. Only in relatively few sections the form of its lumen appears as much changed as in Case 7. Moderate infiltration with pus-cells in the tissue of the iris.

b. Right eye. In the inner superior quadrant of the cornea, an irregularly elliptic ulcer, 6 mm. long, one long side of which coincides with the corneal margin. The bottom of the ulcer is formed by a prolapse of iris, which does not project over the level of the cornea. The perforation occurred eleven days before death. In the perforated space the iris consists of two layers, one ascending and one descending. Descemet's membrane adheres to the wall of the canal, and lying close to it and following all the folds of the iris, it ascends nearly to the level of the anterior surface of the cornea. Cornea and iris considerably infiltrated with pus-corpuscles; the vessels of the latter strongly filled. The cavernous tissue of Fontana's space is thickly set with pus-corpuscles. But even where the infiltration of the tissue of the scleral channel is most intense, the surrounding sclera itself shows no infiltration. In meridional sections the canalis Schlemmii cannot be recognized. In some places a layer of greenish coagula, to which a few pus-gobules adhere, is lying upon the iris. The iris is nowhere in contact with the cornea, even not in those parts of the periphery of the chamber which corresponds to the prolapse.

9. *Karl Zust*, 32 years old, boiler-maker, was injured on April 28th, 1874, by a small plate of metal which perforated the centre of the cornea, and remained in the lens. It was irregularly elliptic, 6.5 mm. long, 4.5 mm. broad, and about 0.2 mm. thick. On June 5th, when the patient came under treatment, there was moderate ciliary injection, the cornea transparent and shining, and had in its outer half an arched cicatrix with its concavity outwards. The chamber was shallow with a hyphæma $\frac{4}{5}'''$ in height. The iris was discolored, and an intensely greenish-yellow reflex came from the fundus of the eye. The sight was lost. Tension far below normal, pain on touching very great.

On July 11th, this globe was enucleated for a sympathetic visual defect in the right eye. Then two-thirds of the chamber were filled with blood. The anatomical examination showed a very considerable irido-cyclitis with detachment of the retina. The piece of metal was lying a little behind the iris, imbedded in lens-matter and pus-cells. The point of interest here is that the anterior chamber as well as the cavities in the tissue, from the margin of Descemet's membrane to the ciliary muscle and in the scleral channel were perfectly stuffed with white and red blood-corpuscles, especially red ones. I was very much surprised by the sharp limit between this alveolar tissue, pervaded by blood-discs, and the sclero-cornea, by the perfect conformity of the infiltrated mass with the contents of the anterior chamber, and by the simply passive condition of the tissue of Fontana's space, the cavernæ of which are so strongly infiltrated. The diameter of the whole mass of this tissue has naturally become much larger; this is recognized by a more complete narrowing toward the anterior chamber and by occlusion of Schlemm's canal. The lamellæ which are lost in the ciliary muscle appear radiating in meridional sections. (A very similar condition I have described in case 2, in which the hemorrhage had occurred after an iridectomy.) The sinus of the chamber was normal, the ciliary body being markedly drawn toward the axis of the eye. The ligamentum pectinatum was not attached to the corresponding portion of the posterior wall of the chamber.

(*To be continued.*)

SOME OBSERVATIONS AND REMARKS ON THE ACTION OF ESERIN IN GLAUCOMA.

By H. KNAPP.

SINCE the end of the year 1877, I have methodically used eserin in the majority of cases of glaucoma that have come under my notice. The results in some have been so striking that I wish to make known the experience hitherto gained, not as something definite, but as a modest contribution to the knowledge of the "antiglaucomatous" effect of eserin, discovered two years ago by Prof. LAQUEUR, of Strassburg.

Especially interesting are two patients, the one affected with acute glaucoma in one eye, the other in both. In the first, eserin was instilled from the second day of the disease, its action was prompt and complete, and the patient permanently cured. In the second case, the remedy was employed no sooner than two weeks after the onset of the glaucoma, its action was marked, yet relapses occurred, and iridectomy had to be resorted to. During the recovery, the first symptoms of glaucoma appeared in the fellow-eye. They were at once removed by eserin, but returned with increased intensity, yet were again removed by eserin. In a third and fourth relapse, the remedy produced only a remission of the symptoms. I was therefore obliged to perform iridectomy, by which the eye was permanently cured.

The following histories will supplement these comprehensive remarks.

CASE I.—H. M., a healthy Jewess of New York, æt. 35, came to my office Jan. 10th, 1878, with a small phlyctenular ulcer at the external corneal margin. Only three days previously, she had noticed the first traces of an eye trouble, and the small ulcer was without any complication. I ordered a half-per-cent solution of atropia to be dropped into the eye three times daily.

Four days later she returned, the ulcer was cured, the eyeball free from any irritation, sight perfect. For a low degree of swelling of the palpebral conjunctiva, I prescribed a weak solution of sulphate of zinc, telling her she should leave the former drops off, and need not come again, since her eye was cured.

On the 21st Jan., however, she returned with a severe attack of acute glaucoma in the same eye. The day before, her eye and its surroundings began to pain her, the ball was red, and sight cloudy. In the evening, she instilled one drop of the atropine solution which she had not used for six days. It increased the pain, though formerly it had no unpleasant effect whatever. She passed a sleepless night, having severe and constant pain in her eye and around it. Early in the morning, she came to me with the following symptoms: œdema of the lids, lachrymation, marked injection and some chemosis of the conjunctiva, cornea and pupil hazy, anterior chamber shallow, pupil somewhat more than middle-wide, immovable, background of eye veiled, disc and blood-vessels too indistinct to recognize pulsation, tension of the eye greatly increased, S. $\frac{15}{200}$, F. complete.

I told her that she had glaucoma, for which I would try a new remedy, but I would call on her in the afternoon, and, if her eye was no better, it should be operated on without further delay. I ordered a two-per-cent solution of sulphate of eserin to be instilled, one drop every hour; I further advised her to go to bed, take an aperient, put 6 leeches to the temple, and keep the after-bleeding up for one hour and a half.

When I saw her at 4 P.M., I found that she had strictly followed my orders, and the result was admirable. The pain had almost left her, the œdema of the lid and the swelling and injection of the conjunctiva had diminished, the cornea and iris were clear, the pupil was fully contracted, and, despite its narrowness, I obtained a clear view of the fundus. The papilla was well defined, arteries regular, not pulsating, veins dilated, remainder of fundus normal. The tension of the eyeball was normal, and even lower than that of the other (healthy) eye. The patient could count my fingers across two rooms, and read ordinary print by candle light. The inflammatory glaucomatous attack thus having completely subsided, I advised the patient to remain in bed, and instil the eserin drops every two or three hours.

When I saw her the next day, I found the œdema and redness further reduced, and the other conditions as favorable as the day before. The improvement continued steadily. I ordered eserin to be instilled less frequently. On the seventh day her sight with — 2.5 D. was $\frac{20}{20}$. One drop of a fresh two-per-cent solution of eserin, which I dropped into her eye at my residence on the ninth day, made her eye red and gave her pain above the brow, lasting for two days. I advised her to remain in a moderately darkened room about a week, then gradually go out, but to continue the eserin for two to three weeks. Her recovery was undisturbed and complete. When I saw her June 15th, almost five months after the onset of the attack, her eye was normal in every respect, and she has used it without any inconvenience by day and by night.

Case II.—C. L., Irish, healthy, æt. 37, was first seen by me at the beginning of February, 1878, after having had in her left eye pain, redness, and diminution of sight for two weeks. She presented a full picture of acute glaucoma. T. 2, circumcorneal injection, cornea dull, anterior chamber shallow; pupil wide, oval, and immovable, media turbid, fundus not visible, S. $\frac{10}{200}$, F. complete, ocular and circumorbital pain. She was ordered eserin every hour, rest in bed, six leeches to temple, and an aperient. The pain subsided at once; she passed a good night, and when I saw her the next day, the globe had normal tension, the pupil was narrow, though not so much as in a healthy eye, into which eserin has been dropped; the media had cleared up; the details of the fundus showed marked dilatation of the retinal veins, but no other abnormity. She was able to read moderately large print. I advised her to continue the use of the eserin drops, to stay at home, but not darken her room, as I thought that light might be favorable by assisting the myotic effect of the eserin. The attack disappeared, yet the pupil was never completely contracted.

A week later, the patient had another acute attack of the same intensity, which was treated and cured in the same manner.

Ten days after that, she had a third attack, to cure which she was admitted to the Ophthalmic and Aural Institute. Under the same treatment the symptoms abated, but the tension remained increased, and the optic disc began to be cupped. Then there appeared, in spite of the eserin treatment, a new increase of tension and an aggravation of the inflammatory symptoms. An iridectomy was performed without further deliberation. The operation was *lege artis* and clean, yet the restoration of the anterior chamber slow. The tension remained increased for several months, in spite of the continued use of eserin.

Four days after the operation, there was even a new attack of glaucoma. Pain considerable, circumcorneal injection, etc. Ordered five leeches to temple. Relief. Ultimate and lasting result moderately good. Tn., media clear, slight cupping of disc, F. somewhat contracted on nasal side, S. $\frac{20}{50}$.

Seven days after the operation on the left eye, the right eye, which before had been healthy, became painful, tension increased, pupil sluggish, sight dim. Ordered: leeches, eserin, aperient. The next day pupil fully contracted, sight and tension normal. Eserin left off four days after recovery from this attack. The following day, a new attack of glaucoma, which was cured in the same way. Four days later, obscuration again. Five leeches to the temple and eserin. Tension reduced, pupil contracted, but not so fully as before. Five days later, T. again increased, media turbid. Leeches were applied, eserin continued, iridectomy proposed, and performed the day after. Recovery prompt, complete, and lasting. At present, ten weeks after the operation, Tn., S. $\frac{20}{20}$, F. complete, anterior chamber of normal depth, media clear, no excavation, no atrophy of disc.

In another case, acute glaucoma set in in a previously healthy eye, seventeen days after the other had been operated on for chronic glaucoma, and had made a good recovery. Eserin applied to the eye suffering from acute glaucoma produced a temporary abatement of the symptoms, whereas a prompt and permanent cure was effected by an iridectomy. The history of the disease is as follows:

Case III.—Julia H., a healthy Jewess of New York, æt. 49, consulted me March 23d, 1878. Her left eye had been weak since the end of August, 1877. At that time it was red and painful, and she saw haloes around the light. An oculist whom she consulted advised iridectomy, but she refused. The inflammation gradually subsided. When I saw her first, there was no irritation in that eye. The pupil was sluggish and larger than that of the other normal eye. S. $\frac{20}{100}$. Nasal half of F. wanting. T. 1, anterior chamber shallow. Optic disc deeply excavated. Iridectomy was performed March 23d, 1878, at the New York Ophthalmic and Aural Institute. The anterior chamber re-established gradually; the scar, raised at first, soon became firm; the iris, which, during the first two days was seen in the bulging inner corner of the wound, retracted. When the patient was discharged, thirteen days after the operation, the anterior chamber was restored, the cicatrix flat, both sphincter edges of the coloboma were free; the tension was normal; the eye was free from irritation, and has remained so. June the 13th, 1878, almost three months after the operation, S. was $\frac{20}{70}$, and the field of vision somewhat larger than before.

Seventeen days after the operation, the patient presented herself again with the following condition of the other, right, eye: cornea hazy, pupil middle-wide, immovable, background veiled, T. 1. Colors around light; pain and circumcorneal injection, sight very dull, F. complete. The attack began four days previously, and had steadily increased in intensity. She was again admitted to the institute, treated with the ordinary two-per-cent solution of eserin every two hours, six leeches to the temple, and an aperient. The relief was immediate. The pupil contracted; the cornea and media cleared rapidly, and the tension became normal. Towards evening of the next day, despite the continued use of the eserin, pain and lachrymation set in again; the pupil became wider, and she saw rainbow colors around the light. As, on the day after, the symptoms had not abated, iridectomy was performed. The anterior chamber was restored on the fourth day; the patient was discharged cured a week after the operation. On June 13th, two months after the operation, her sight was $\frac{20}{50}$, Tn., F. complete

In *chronic glaucoma*, my experience with eserin has been larger. The results have been either negative or unfavorable. The application of eserin narrowed the pupil and reduced the tension more or less, but in several cases marked episcleral injection, lachrymation, and pain in the brow appeared during the instillations, and lasted for some days after the remedy had been left off. As an example, I may report the following:

CASE IV.—Rev. R. N., Christian, of New York; æt. 57, had a brother and sister both blind from glaucoma. He was operated by me for chronic glaucoma in both eyes, August 31st, 1876. Before the operation, S. was $\frac{5}{200}$ R., and $\frac{20}{70}$ L.; F.R. greatly contracted, L. complete. Operation and recovery good; S. remaining as before. He could see nicely, and had no inconvenience until November 21st, 1877, when a sudden blur came before the left eye, as the cause of which the OS. discovered numerous hemorrhages in the course of the dilated retinal veins. S. $\frac{1}{200}$ in the right eye, S. $\frac{0}{200}$ L. I ordered him leeches and an aperient powder. The hemorrhages gradually absorbed, and on January 22d, 1878, his vision was $\frac{20}{70}$ again.

The right eye had from time to time been somewhat troublesome, and showed January 22d, T. 1; S. $\frac{1}{200}$. Since the left was restored to its *status quo ante*, I tried the effect of eserin on the right eye, one drop of a two-per-cent solution to be instilled every three hours. He had severe pain after the application of the remedy, which lasted all night, and was still present when he came to see me the next day. I found his pupil narrower than the day before, the tension about normal, but the episcleral veins were greatly enlarged and tortuous. This condition lasted for several days.

In no case of chronic or subacute glaucoma have I seen any benefit from eserin; on the contrary, it exaggerated some, as is exemplified by the following case, in which it positively did great harm in producing a severe attack of acute glaucoma.

Case V.—E. St., a Jewess, of New York City, æt. 68, had had in her left eye glaucomatous symptoms for a year. When she came to the Dispensary, January 30th, 1878, that eye presented a shallow anterior chamber, opacity of the lens, excavation of the optic disc, S. $\frac{10}{200}$, no ascertainable limitation of the visual field, no marked symptoms of irritation, but somewhat increased tension. She was told that the eye had to be operated on. As she wanted to go home first, she was advised to use eserin, and return the next day. Her daughter came three days afterward, stating that her mother had used the drops, but her eye had become so red and painful, and she had felt such pains in her head, as to be unable to leave her bed. I told her to bring her mother to the institute, since only an operation could save her eye. When the patient came, on February 4th, five days after the application of eserin, she still showed the symptoms of an acute attack of glaucoma. She could only see the movements of the hand. F. was not to be ascertained, T. 1. An upward iridectomy was made, from which the eye did not recover. The anterior chamber was not restored for weeks, and the vision remained reduced to mere perception of light. The operation had been without accident, and the eye soon became free from irritation.

I have employed eserin also in a case of *absolute glaucoma*, unfortunately without any benefit. The case briefly related is as follows:

Case VI.—Edw. H., a Christian, of Bergen Point, New Jersey, æt. 67, admitted May 3d, 1878, lost his right eye some years ago. It was shrunken after repeated operative interference. The left has been blind for more than a year, showed cataract, intense ciliary irritation, and great increase of tension, no perception of light. The pain in the eye, its surroundings, and the head has, during the last months, been so great and constant, all remedies to relieve it having been exhausted, that he only asked to have this eye removed in order to get rest. Before complying with his request, I ordered leeches to the temple, and eserin to be dropped into the eye three to nine times daily. After this treatment had been continued four days without any relief, I removed the eye; the patient lost all his pain, was contented and felt happy.

Preparatory to iridectomy, in order to operate under more favorable conditions, both as to tension of the globe and size of the pupil, I have often used calabar bean extract and sulphate of eserin, and though I fully appreciate its advantages, there seemed, in some cases, also a disadvantage to be inherent to the remedy; that is, its tendency to produce congestion and inflammation of the iris. Of this I had an example quite recently.

Case VII.—C. P. D., Christian, æt. 48, of Brooklyn, had in his left eye periodic obscurations of the visual field, chromatopsia, circumorbital neuralgia, and diminution of sight for four months. *Status præsens* on June 10th, 1878: T. 2, pupil wide, immovable; sensibility of cornea reduced, anterior chamber very shallow, media clear. Moderate cupping of o. d. The most pronounced pulsation of the blood-vessels on the disc I ever saw. The arteries and veins pulsate simultaneously, and the pulse of both is synchronous with that of radial artery. Patient suffered from palpitation of the heart, and had a systolic murmur. F. contracted on nasal side, above and below; S. $\frac{20}{200}$. I admitted him to the hospital, had leeches applied to the temple and eserin used. The next day the tension of the eyeball was reduced, but still exceeding the normal standard; the pupil was narrow, the iris lustreless and apparently swollen, fine circumcorneal injection, and slight œdema, exhibiting the features of an acute iritis.

The upward iridectomy was made without accident, no instillations after it. The artificial pupil was clean, the lips of the wound applied well, yet the anterior chamber was not restored for several days, the finely striated circumcorneal injection persisted, and an anterior synechia with a short white horizontal streak in the cornea made its appearance on the lower inner border of the pupil. I ordered atropine instillations; the pupil dilated moderately, the anterior chamber became deeper, the irritative symptoms subsided, S. grew better, T. was normal, but on June 19th, when I saw him last, the synechia was still present.

In cases of *corneal fistula*, for which eserin is so much praised, I have seen only moderate benefit.

In one case, of several years' duration, the remedy had no effect. A large iridectomy closed the fistula, and the glaucomatous attacks thus far, three months, have not reappeared.

In another case, likewise of some years' standing, in which I had made an iridectomy without closing the fistula and without preventing the periodic glaucomatous attacks from returning, the remedy showed no other effect than to produce marked pain over the brow.

In a third case, in which the fistula had gradually been converted into a small staphyloma, I abscinded the protrusion, and since the wound showed a low tendency toward closure, I had eserin dropped into the eye three times daily. The remedy, in this case, was well borne, and seemed to accelerate the union of the small wound.

In a fourth case, I have no doubt that eserin did a great deal of good. It was that of a man whose left lens had been dislocated into the anterior chamber in consequence of an injury. Repeated irritation for years had been the consequence. The removal of the lens by a lower section was followed by escape of vitreous, which kept the wound gaping for a week, and there was slow progress in its closure. On instillations of eserin, three times daily, the pupil became narrow, the wound united more rapidly, and was closed in ten days.

If I critically review the series of cases of glaucoma in which I have used eserin, and of which the above-described observations form the most striking examples, I essentially have to concur in the statements of *Laqueur* and *A. Weber* and others, though some opinions that have been advanced on the action and the use of eserin are not borne out by my experience. The sanguine hope with which the brilliant result in the first case of an acute glaucoma had inspired me soon vanished, and thus far I can only assert that eserin cures acute glaucoma permanently in exceptional cases; in the others it produces a temporary improvement, by which the patient may be beneficially prepared for the operation. In subacute glaucoma (case vii.), its effect is doubtful, and in chronic glaucoma, with or without subacute exacerbations, the remedy either has no effect at all, or is injurious (case v.). In corneal fistula and slow closure of corneal wounds from intruding vitreous, eserin may be of great assistance. Glaucoma supervening in the second eye during the recovery from an iridectomy of the first, was, in the cases that came under my care, not cured by eserin.

The tendency to produce iritis, which seems to accompany the myotic effect of the remedy in irritable eyes, and the fact that eserin may cause an acute attack in a case of chronic glaucoma, seem to warn us against the indiscriminate use of this powerful myotic. I shall unhesitatingly begin to treat cases of acute glaucoma with eserin, leeches, aperients, and anodynes, as we treat acute iritis with atropine, etc. If the pupil fully contracts and the attack is completely cured, an operation may, perhaps, never be necessary; but if the remedy produces incomplete myosis and incomplete reduction of the tension of the globe, or if relapses occur, iridectomy should not be delayed. In cases of subacute and chronic glaucoma, I shall resort to iridectomy at once. Preparatory to iridectomy, I would employ eserin only when the eyeball is extraordinarily hard, the pupil very wide, and the anterior chamber so shallow as to render a smooth performance of the iridectomy difficult, or expose the eye to intraocular hemorrhage, in consequence of the sudden reduction of the high extravascular pressure. The prophylactic use of eserin in the healthy eye during the first time after a glaucoma operation on the other, which *Wecker* recommends, may be good practice. The cases reported above, in which eserin did not arrest the development of glaucoma in the other eye, are no evidence against Wecker's statement, since eserin was not used before the first symptoms of glaucoma had made their appearance.

A CASE OF SPONGY (FIBRINOUS) IRIDO-CHOROIDITIS, AFFECTING BOTH EYES AT AN INTERVAL OF SEVEN MONTHS.

By H. KNAPP.

In my last paper on cataract extraction, I gave, at page 121, etc. (Vol. VI. of these ARCHIVES), a general sketch of that peculiar form of exudation into the anterior chamber and vitreous body, of which *H. Schmidt*, *Gunning*, *Gruening*, and *Kipp* have published some clinical observations, under the names of lens-like, gelatinous, or spongy exudation. Its nature is a fibrinous deposit, as Dr. A. Alt has shown by the microscopic examination of an extirpated eyeball (see the previous number of these ARCHIVES), and I by examining a specimen extracted from the anterior chamber after an operation—iridectomy—for glaucoma (see the paper mentioned above). The following case offers some new features which may be placed on record, since they may aid in drawing the clinical picture of this peculiar affection.

In May, 1877, a healthy-looking man of 27 years of age presented himself to me with a rather severe iritis, of ten days' duration, in his right eye. He had had gonorrhœa shortly before. As he did not live in the city, he was admitted for treatment to the N. Y. Ophthalmic and Aural Institute, where I had an opportunity of closely watching his case. The upper part of the pupil dilated soon after the application of leeches to the temple, instillation of atropine, the administration of an aperient, and keeping the patient in bed in a dark room. The lower part dilated incompletely, showed an irregular edge, but no marked excrescences. Two days after his admission, the lower half of the iris appeared duller than the upper, and the lower half of the pupil was occupied by a lattice-work of irregularly interwoven, partially delicate, and partially coarse, grayish fibres. The third day, the whole anterior chamber was turbid, the whole iris dull, but the lower half more than the upper, and the lower half of the pupil was covered with a dense, spongy-looking, gray, somewhat yellowish mass. The fourth day, the whole anterior chamber was filled with a grayish, semi-transparent substance, which did not appear compact, but rather like a silk-worm cocoon. The irritative symptoms, which had been moderate at first, but increased daily, were now at their height. Œdema of lids and conjunctiva, some sero-mucous discharge, marked circumcorneal injection, not finely striated and light-red, as in acute simple iritis, but rather dark-red, the blood-vessels being dilated, tortuous, and reaching as far as the equator of the globe, circumorbital pain, increased in the night; sight reduced to the perception of the hand, tension normal, field of vision complete. On the fifth day, the irritative symptoms abated; the exudation in the anterior chamber had a more uniform, gelatinous aspect. From the sixth day, it began to contract and absorb. The exudation looked like a dislocated lens, the upper edge of which was sharp and well-defined, leaving a crescent of clear iris uncovered. Five days later, the whole mass was absorbed, the pupil free and widely dilated, the episcleral injection was reduced to a small zone around the cornea, the œdema of the lids and conjunctiva had disappeared.

The patient being able to count fingers at the distance of several feet only, I examined the interior of the eye with the ophthalmoscope, and found the whole vitreous diffusely opaque, the retinal veins dark-red, dilated, and tortuous; the arteries thin, difficult to be seen. In the lower part of the fundus was a grayish opacity, larger than the optic disk, covering the retinal vessels, its edges gradually fading away. From day to day, the interior of the eye cleared up, the gray patch was gradually but completely absorbed, and twenty-five days after the admission of the patient—that is, thirty-five after the beginning of the disease—the fundus was entirely clear, sight restored, yet there was still some congestion of the retinal veins.

For seven months the patient was completely well, using his eyes in reading and writing, from early in the morning till late in the evening, without any inconvenience.

Jan. 23*d*, 1878.—He again presented himself at the Ophthalmic Institution with a severe iritis, which had suddenly appeared in the other, left, eye, two days previously. The right eye was perfectly healthy. The same treatment was ordered.

Jan. 24th.—Pain; pupil wide and clear; extensive circumcorneal injection; œdema of upper lid; Tn.

Jan. 25th.—Anterior chamber turbid; in lower half of pupil a network of fine filaments, densest near the edge of the iris; severe pain; morphium at night.

Jan. 26th.—Extreme circumcorneal injection, chemosis, œdema of lids, severe pain; pupil wide and regularly round; the whole anterior chamber filled with a spongy, gray exudation; Tn.; sees movements of hand.

Jan. 27th.—Status idem.

Jan. 28th.—The spongy mass contracted, gelatinous, presenting a sharp margin at the upper circumference; less pain.

Jan. 30th.—The exudation sharply defined on all sides, incompletely filling the anterior chamber, resembling a semi-transparent lens, having a notch in its upper edge; irritative symptoms abating.

Feb. 1st.—Considerable pain during the night, photophobia, lachrymation; intense injection of globe; the whole anterior chamber dull and cloudy; Tn.; free from pain during the day.

Feb. 2d.—Less pain than during the previous night; anterior chamber cloudy, as before.

Feb. 3d.—The periphery of anterior chamber cleared up; oblique illumination shows a *second layer of whitish-gray exudation, covering like a watch-glass the previous lens-shaped exudation.* Its edges are sharp and notched in different places. No pain.

Feb. 5th.—Circumcorneal injection diminishing; both layers have almost disappeared, leaving only small remnants in the pupillary space. Fundus veiled by diffuse opacity of the vitreous.

Feb. 8th.—Injection less; fundus still cloudy.

Feb. 11th.—Vitreous clearer, but details of fundus still very indistinct; six leeches to the temple.

Feb. 14th.—Retinal veins recognizable, dark and tortuous; arteries hardly visible.

Feb. 19th.—Episcleral injection almost completely disappeared. Vessels of retina clearly seen. No trace of exudation in anterior chamber; pupil widely dilated by atropine; free from adhesions; Tn.; Fc.; no pain; patient discharged.

March 1st.—Interior clear; sclerotic white; atropine discontinued; no sequels of the disease left; S. $\frac{20}{20}$; duration of the inflammation, five weeks; recovery perfect.

June 15th.—Had no relapse; both eyes normal.

The *novel features* of this case are:

1st. The occurrence of the same disease on the left eye without any apparent cause, after the right had been cured seven months.

2d. A second effusion of fibrinous exudation, when the first was in the way of absorption. I have recently seen this in another case. Though these conditions are by no means uncommon in other forms of iritis and choroiditis, I have not before observed them in spongy exudation, nor have they, if my memory serves me, been described by others.

In conclusion, I may mention that the severity of the inflammatory symptoms in the above case would have led me to frame an unfavorable, or, at least, doubtful prognosis, had I not recognized at an early stage the peculiar form of the exudation.

The binocular inspection with a large lens, by focal illumination, is a great help in seeing both the primary network of filaments and the spongy character of the fibrinous exudation, thus enabling us to make the diagnosis before the contraction and beginning absorption render the exudation lens-like or gelatinous.

ON PERIPHERAL DIVISION OF THE CAPSULE IN MORGAGNIAN CATARACT.

By Dr. EMIL GRUENING, of New York.

In a paper published in the January and February number (1878) of the Annales d'oculistique, and entitled: "Sur les causes ordinaires d'insuccès dans l'extraction de la cataracte de Morgagni (cataracte à noyau flottant) et sur les moyens d'en triompher," Martin puts forth a number of propositions, which may be formulated synoptically as follows:

1. The delivery of Morgagnian cataracts is at times very easy, the contents of the capsular sac, fluid cortical substance and nucleus escaping after division of the capsule upon the slightest pressure; at times, however, altogether impossible, the fluid substance oozing out slowly and the nucleus remaining in the sac in spite of all expulsive efforts.
2. This diversity of results is not due to any inherent differential quality of the cataracts, but depends solely upon the modus faciendi, which, when the first result ensues, has been practised correctly but unconsciously by the surgeon.
3. The nucleus remains in the capsular sac, either because the opening made in the anterior capsule is too small to allow of its passing out, or because
4. The expulsive efforts are insufficient to accomplish the desired object.

In order to secure against the retention of the nucleus, and effect its easy passage in every case of Morgagnian cataract, Martin recommends the following operative steps:

a. Corneal section, Lebrun's upper median flap.

b. Iridectomy, if required.

c. Extensive horizontal division of the capsule in the largest diameter of the lens with v. Graefe's cystotome.

d. Expulsion of the contents of the capsular sac by depression of the upper lip of the corneal wound in the manner practised by Weber.

Martin lays particular stress upon the correct execution of the third step, *i. e.*, extensive horizontal division of the capsule in the largest diameter of the lens.

In the course of the last eight years, I had occasion to observe difficulties in the delivery of Morgagnian cataracts repeatedly, twice in my own operations, and several times in extractions performed by a skilled and renowned operator. In all these cases, the difficulties were finally overcome, and though I have never met with a case of Morgagnian cataract in which the extraction of the nucleus proved impossible, I can readily understand that such an adverse circumstance might occur. One of my friends, an oculist of established reputation, assured me that twice he had been obliged to leave the nucleus of a Morgagnian cataract in the eye.

In the month of October, 1877, a woman, having Morgagnian cataract in one eye, and immature cataract in the other, presented herself for operation. Mindful of the embarrassment occasioned me in the two instances alluded to above, and being aware that the ready expulsion of the cataract depended chiefly upon the proper direction, size, and locality of the capsular wound, I determined to deviate from the ordinary mode of performing the third step of the operation, *i. e.*, division of the capsule.

On the 25th of October, 1877, I extracted the Morgagnian cataract with the assistance of Drs. Born and Edward Fridenberg in the following manner:

a.) V. Graefe's peripheric linear section upward, with slight encroachment upon the transparent cornea.

b.) Broad iridectomy.

c.) *Division of capsule along the upper periphery of the lens by a rapid movement of a sharp v. Graefe's cystotome.*

d.) Gentle depression of the upper lip of the corneal wound with a broad metallic spoon and pressure upon the eyeball at the lower portion of the cornea with the back of a hard rubber spoon.

The milky cortical substance, together with a nucleus somewhat longer than usual in Morgagnian cataract, rushed forth with great readiness. The wound healed nicely, and the patient was discharged ten days after the operation. Her ultimate vision was $\frac{20}{70}$, no secondary operation having been performed.

In comparing my method of opening the capsule in Morgagnian cataract with that proposed, but, as it appears from his paper, as yet not practised, by Martin, it is not my purpose to discuss the question as to whether v. Graefe's combined peripheric linear incision should be resorted to as a general method in preference to Lebrun's upper median flap-section, with or without iridectomy. I am of opinion that, in the operation for Morgagnian cataract, Lebrun's section is not admissible, because it renders peripheral cystotomy impossible, and consider v. Graefe's combined peripheric linear section highly commendable, as it prepares the way most efficiently for a successful peripheral incision of the capsule.

In ordinary cystotomy, especially when vertical incisions have been practised, the expulsive efforts force the nucleus into a peripheric capsular cul-de-sac, from which it cannot be dislodged with ease. Continued pressure avails nothing, as the nucleus is too small to execute the bascule-movement required for its engagement in a centrally located capsular wound.

The object of peripheral cystotomy in Morgagnian cataract is twofold: firstly, to abolish the peripheric capsular pouch which impedes the egress of the nucleus, and secondly, to evacuate the liquid cortical substance directly, without bringing it in contact with the iris. Martin desires to gain the same ends by rather inadequate measures. As he begins his operation with Lebrun's section, he is obliged to practise his horizontal cystotomy through the anterior pole of the lens. He thus forms a large upper capsular pouch, from which he endeavors to dislodge the nucleus by depression of both the upper corneal and capsular wounds.

In November, 1877, Knapp adopted peripheral division of the capsule in the extraction of cataract, and in a paper published on this subject in the sixth volume of these ARCHIVES records the results obtained in a series of twenty-nine cases thus operated upon by him, and recommends peripheral cystotomy as a general method.

OPHTHALMOLOGICAL REVIEW.

By E. GRUENING and H. KNAPP.

1. Magnus, H. Der Augenärztliche Stand in seiner geschichtlichen Entwickelung. (Reprint from the *Archives of the History of Medicine and Medical Geography*. Leipzig, 1878.)

2. Koenigshoefer, Oscar. On Jaborandi and Pilocarpine as Regards their Action upon the Eye. *Klin. Monatsbl. f. Augenhlkde.*, June, 1878, p. 251.

3. Wecker, L. de On the Comparative Use of Eserine, Atropine, and Duboisine. *Klin. Monatsbl. f. Augenhlkde.*, May, 1878, p. 218, etc.

4. Deutschmann, R. Klinische und experimentelle Beiträge zur Resorption pathologischer Inhaltsmassen in der vorderen Augenkammer. *Graefe's Arch. f. Ophth.*, xxiv., P. II., p. 213, etc.

5. Hosch, F. Zur Lehre von der Sehnerven-Kreuzung. *Klin. Monatsbl. f. Augenhlkde.*, June, 1878, p. 281, etc.

6. Schweigger, A. Th. C. Ueber Glaucom. Volkmann's Collection of Clin. Lectures. Leipzig, 1877.

7. Wecker, L. de. On Glaucoma. *Klin. Monatsbl.*, May, 1878, p. 189, etc., and *Annales d'Oculist.*, 1878.

8. Schweigger, Prof. Ueber sympathische Augenleiden. *Berl. Klin. Wochenschrift*, p. 281, May 20th, 1878.

9. Mauthner, L. Die sympathischen Augenleiden. (Lectures on Ophthalmology, I. Number. The Sympathetic Affections of the Eye.) Wiesbaden. J. F. Bergmann, 1878.

10. Graefe, Alfred. Die antiseptische Wundbehandlung bei Cataract-Extractionen. (The Antiseptic Treatment in Cataract Extractions.) *Graefe's Arch.* xxiv., 1, p. 233, 1878.

11. Hirschberg, J. Division of the Ciliary Nerves. *Berl. Klin. Wochenschrift*, p. 291, May 20th, 1878.

12. Hirschberg, J. Zur Prognose der Glaucom-Operation. *Graefe's Arch.*, xxiv., 1, p. 161, 1878.

1. Magnus gives, in a paper of thirty pages, an interesting account of

the historical development of the *ophthalmological profession.* Thousands of years ago, the ophthalmology of the Egyptians enjoyed a high reputation through the world, as far as the world was civilized at that time. The practice of medicine was in the hand of the powerful priesthood. A patient did not send for a particular physician, but to a temple, and the priesthood selected for him the medical man whom they thought best qualified to treat his case. Thus the study of specialties was encouraged. The physician received no fee for his services, but was supported by the temple, to which patients when cured used to make gifts. The priest-physician was bound to treat his patient according to the rules prescribed in the sacred books, since the legislature believed that there were only a few men whose intelligence was so great as to improve on the modes of treatment laid down by the most skilful physicians.

In ancient Greece, essentially the same customs prevailed, and the temples of Diana were particularly celebrated for the cure of eye diseases.

In Roman history, especially during the Empire, we meet the ignorant traveling eye surgeon, who, by his vile practices, seemed to have monopolized ophthalmic art in such a way as to make its profession repugnant to respectable physicians. To prove this, the author states "that Galen had long hesitated in writing a treatise of scientific ophthalmology, in particular of its optical part, since he knew how distasteful such doctrines were to oculists." (De Usu Part., lib. x., cap. 12.)

Throughout the middle ages the ophthalmic profession, both in its character and social standing, was degraded. The better oculists were mere imitators of the ancients, and whatever progress the history of ophthalmology has to record in these centuries, it owes to the labors of non-oculists; for instance, Salvini Amati (invention of spectacles), Alexander da Spina, Maurolycus, and others. The "traveling oculist" was a numerous tribe and a kind of outlaw among medical men, for Fabricius ab Aquapendente states that he had given up the performance of cataract operations, since he was afraid of the hatred and persecutions of oculists. On the other hand, their own lives were not safe. King John, of Bohemia, in 1337, had an oculist of extensive practice thrown into the river Oder, on account of his being unable to make his weak eyes strong.

Ophthalmology as a science begins with the eighteenth century, by the labors of Brisseau, Maitre-Jean, Boerhaave, Heister, St. Ives, Morgagni, and others, and the *art of ophthalmology* assumed a more dignified aspect, though even such eminent men as Daviel, v. Wenzel, Assallini, Jung Stilling, and others still "traveled," yet they possessed great skill, high scientific attainments, and endeavored to hold up the honor of their profession. Still a worthier position eye-surgery gained in the beginning of the present century, by its admission into the regular plan of studies at the European high-schools. This advance movement was ushered in by the establishment of a chair and clinic of ophthalmology at the University of Vienna. That chair, from his first incumbent, the celebrated Beer, has always been occupied by excellent men. Other German universities followed the good example, and with men like Himly, Langenbeck, Jaeger, Walther, Chelius, Schmidt, etc., the traveling oculist, even of the type of the Englishman Taylor, could no longer compete. The development of ophthalmology in the last three decades is not spoken of in Magnus' paper. K.

2. At the close of a series of experiments instituted with a view of testing the action of jaborandi and pilocarpine upon the eye, K. sums up his results in the following propositions:

(1.) The spirituous and aqueous extracts of jaborandi, locally applied, have no effect upon the eye save a purely mechanical irritation of the conjunctiva. The active principle of jaborandi is obviously not contained in either of the extracts.

(2.) The internal administration of jaborandi causes moderate spasm of accommodation, approximation of the near point, coruscating scotoma, and a slight increase in the secretion of tears.

(3.) Muriate of pilocarpine, locally applied, causes *excessive* myosis and slight spasm of accommodation; subcutaneously injected, excessive spasm of accommodation, with approximation of the near point, *slight* myosis, and an increase in the lachrymal secretion. G.

3. WECKER sums up as follows:

The principal properties of *eserine* are:

(1.) Reduction of the tension of the eyeball.

(2.) Diminution of the conjunctival secretion, in consequence of contraction of the blood-vessels.

(3.) Reduced diapedesis in general.

The principal properties of *atropine* are:

(1.) Increase of the tension of the eyeball, in consequence of dilatation of the vessels, rising in certain cases (of reduced amplitude of filtration) to glaucomatous hardness.

(2.) Increase of the conjunctival secretion.

(3.) Crowding the iris-tissue into the iris-angle. This condition, in cases of perforation of the cornea, is apt to increase the impediments of filtration.

Duboisine is a new and powerful mydriaticum, derived from the Australian tree Duboisia Myoporoïdes, which belongs to the family of Solaneæ. It may be employed in all cases that show a marked intolerance of atropia. Wecker states that he used it without producing the slightest irritation, in the case of a lady suffering from irido-choroiditis, who experienced intense conjunctival irritation after each instillation of atropine. K.

4. D. investigated experimentally the absorption of pathological contents from the anterior chamber, and sums up his results as follows:

(1.) The iris participates most actively in the absorption of pathological contents from the anterior chamber.

(2.) Blood effused into the anterior chamber is absorbed in two ways. A portion of it remains fluid, penetrates unchanged into the iris, and is taken up immediately by the blood-vessels of this tissue, to be restored to the general circulation. The remainder coagulates, and undergoes in all its particles retrograde metamorphoses, fitting it for absorption. The red blood-corpuscles are destroyed after the liberation of their hemoglobine, either before or after they have been incorporated in wandering cells from the iris and the ligamentum pectinatum. The coloring matter set free is collected into granules and crystals which are found uncombined in the iris. Further changes were not observed.

(3.) The mode of absorption of a hypopyon could not be determined directly by experiment. In analogy with the fate of granular pigments and blood injected into the anterior chamber, it seems probable that its elements undergo the same changes and are removed in the same way as the coagulated portion of the hyphæma (with the exclusion of the red blood-globules).

(4.) Sulphate of eserine accelerates the absorption of pathological effusions from the anterior chamber by extending the absorbing surface of the iris to its greatest natural limit.

(5.) The effect of atropine is the direct opposite to that of eserine, as it contracts the absorbing surface.

(6.) Eserine is therefore useful and to be recommended in pathological effusions into the anterior chamber, especially in circumscribed purulent infiltrations and penetrating ulcers of the cornea with hypopyon. It exerts no beneficial action where an iritic complication can be diagnosticated clinically, as is often the case in ulcus corneæ serpens. Here even the greatest extension of the absorbing surface is rendered useless by the inflammatory infiltration of the iris.

(7.) In view of the rôle played by the iris in absorption, the performance of a downward iridectomy seems to be counter-indicated whenever hemorrhage is feared. G.

5. H. reports the history and autopsy of an interesting case bearing on the question of complete or semi-decussation of the optic-nerve fibres in the chiasm. He believes that the solution of this question is reserved to clinical observations and pathological anatomy.

The patient, a man aged fifty-four, had had a slight apoplectic attack in March, 1875, following which the left side of the body remained weak, and the left half of the visual field was lost in either eye. In December, 1875, a second attack occurred, severer than the first. Patient soon recovered, the defect of the visual field remaining.

In February, 1876, H. saw the patient, and found O. D. with direct fixation S. $\frac{16}{20}$, H. $\frac{1}{30}$; O. S.—S. $\frac{16}{30}$, H. $\frac{1}{30}$.

Left half of each visual field completely devoid of sensibility. On both sides the line of division is just outside of the point of fixation (and thus we can understand why with direct fixation S. is almost normal). In the fundus some striped retinal hemorrhages ; both discs somewhat red with ill-defined borders.

A third apoplectic attack in April, 1877, produced a total paralysis of the left side, and was followed by frequent epileptiform seizures, probably due to small hemorrhages. The patient took to his bed, and in December his mental condition was such as to render an examination very unsatisfactory. Still some words in small print could be read when they were held somewhat to the right.

On the 22d of January, 1876, a severe apoplectic attack paralyzed the right side of the body completely, the patient dying two days later.

Autopsy (of brain only).

Extensive atheroma of all arteries down to their finest ramifications ; on the convexity, multiple miliary aneurisms ; immediately behind the chiasm a recent blood-clot, lying on the right optic tract, compressing it and the right side of the tuber cinereum.

On the *right side*, behind the optic thalamus and extending into the inferior cornu, a large cavity, which has destroyed the greater portion of the occipital lobe.

In the vicinity of the corpus striatum, a large pigmented cicatrix, involving the optic thalamus ; corpus striatum and lenticular nucleus markedly diminished in size ; in the scar a cyst as large as a pea.

On the *left side* of the convexity, a small extravasation ; in the white substance of the parietal lobe, a brown cicatrix, the size of a pea. In the region of the third ventricle, the base of which is perforated near the infundibulum, a large recent effusion of blood, the brain-substance very much lacerated.

The optic nerve apparently quite normal, with the exception of the slight impression on the right tract mentioned above. On repeated measurement, the right tract proved to be the narrower and the right nerve the thinner of the two, though but slightly so.

Vertical sections of the chiasm, seen through the microscope, showed a large number of "corpora amylacea" under the covering of pia mater. These, according to Leber, are pathognomonic of atrophy. Whether one side of the chiasm was more affected than the other could not be determined.

Transverse sections of both optic nerves showed unmistakable atrophy of the *inner* fasciculi with numerous corpora amylacea. 1½–2 cm. in front of the chiasm, the sections showed the normal appearance of the optic nerve.

H. argues that, as all old foci (of any extent) were found on the *right* side, in the region of the right optic centre, they alone could be the cause of a hemianopsia of three years' standing. If, with the destruction of the right optic tract, the left eye had become entirely blind, we would assume that complete decussation of the nerve-fibres in the chiasm obtained.

Here, however, all the fibres going to the right halves of the retinæ were paralyzed, and left hemianopsia ensued.

H., therefore, is decidedly in favor of the theory of semi-decussation (as set forth by Gudden). G.

6. SCHWEIGGER states that the inflammatory symptoms in glaucoma do not depend upon the *degree*, but upon the *rapidity* of the increase of intraocular pressure. Smoky opacity of the cornea is the first symptom, opacity of the media is doubtful, that of the vitreous he has never seen. Enlargement of the pupil is produced by a rapidly increased tension ; a slow increase may reach even a higher degree without paralyzing the ciliary nerves, or enlarging the pupil. If, in a case of glaucoma, the pupil is large, we may infer, even if no inflammatory symptoms are

present at the time, that formerly there was a rapid increase of tension. He says that the word atrophic excavation should be discarded, since the bottom of an atrophic optic nerve is still situated at the level of the choroid. The extent of a physiological excavation, as well as the degree of intraocular tension, has a large range surpassing the beginning of the pathological condition. An excavation may be partial, and, nevertheless, glaucomatous in a given person, or, on the other hand, total or almost total, and still be healthy. In such cases, the comparison of one eye with the other will frequently assist us. If S. and F. are normal, the excavation is physiological. If there is a physiological excavation combined with incomplete atrophy of the optic nerve, the limitation of F. will begin on the temporal side, and the perception of colors is deficient, whereas in a glaucomatous excavation connected with atrophy of the optic nerve, the limitation of F. begins on the nasal side, and the perception of colors is good. Sch. cites MAUTHNER, who observed that repeated glaucomatous attacks may lead to atrophy of the disc without cupping, and he adds that in cases of marked hardness of the globe, progressive atrophy and amblyopia without cupping may be arrested by iridectomy. In cases of complete or extensive circular synechia, iridectomy should be made in order to prevent secondary glaucoma, from the same reason a prolapse of iris that does not heal with a smooth scar, but becomes ectatic, should be removed. Glaucoma hæmorrhagicum is, in the great majority of cases, not cured by an operation. Sclerotomy has cured a number of cases, whether in the same percentage as iridectomy or not, is yet unknown. The efficacy of a glaucoma operation does not result from the establishment of a "filtration scar," for Sch. has seen eyes with a cystoid scar after iridectomy get blind by a relapse of glaucoma. He has seen no benefit from eserine in chronic glaucoma, whereas in acute attacks this remedy did good, without preventing relapses. Sch. is an advocate of iridectomy. The theories on the nature of glaucoma which GRAEFE advanced twenty years ago, have been replaced by others, which, in their turn, will perhaps share an equal fate. The fact which Graefe discovered, that glaucoma is curable by an operation, will last. K.

7. WECKER, in accordance with KNIES and WEBER, believes that glaucoma is produced by impeded filtration, on account of obliteration of Fontana's spaces. Glaucoma constitutes about one per cent of the eye diseases that have come under his care. He militates against Donders' theory of hypersecretion, in consequence of irritation of the

fifth pair in eyes not predisposed to glaucoma, though he admits that in "*reduced amplitude of filtration*," periorbital neuralgia, moral excitement, and similar conditions may occasion a glaucomatous attack.

He advocates *sclerotomy* in glaucoma, though in cases involving great responsibility, he does not like to depart from the iridectomy of Von Graefe, whose excellent results have stood the test of time. In sclerotomy he uses sclerotomes of different width, from 2 to 4 mm., the ends of which are lance-shaped. He makes a section in the corneo-scleral juncture, 1 mm. behind the transparent margin of the cornea, the basis of which lies about midway between the horizontal meridian and the upper or lower edge of the cornea. At the apex of the section he leaves a small part of the limbus undivided, but so that Fontana's space is opened along the entire section. Before the operation and for some days after it, sulphate of eserine is instilled. "In general, it is no longer permitted to perform any operation for glaucoma without previously subjecting the patient to the action of eserine ; but we should know that in acute glaucoma the effect of the myoticum is but very incomplete." K.

8. SCHWEIGGER states : When in an eye, affected with irido-cyclitis or irido-choroiditis, not the whole ciliary region is painful on pressure, it is always the upper part, if any, that shows this symptom. Such an eye, if more or less atrophic, may always be suspected of becoming the cause of sympathetic affection in its fellow, and its removal is justifiable, though we should bear in mind that atrophic eyes may for years be painful in the ciliary region without ever producing any sympathetic symptoms, and not all affections that may, under these conditions, occur in the other eye, are of a sympathetic nature. He speaks favorably of the division of the ciliary nerves to prevent sympathetic ophthalmia. He has done it repeatedly. The operation has been complete, *i. e.*, all the nerves may be considered as divided, if the cornea is found insensible, and the ciliary region, when pressed upon, free from pain. *J. C. Vignaux* (Affections sympathiques de l'œil, Paris, 1877) divided the ciliary nerves and the optic nerve with curved scissors, by burrowing under the conjunctiva between superior and internal recti, and thus reaching the nerves, without myotomy. K.

9. MAUTHNER places before us the first number of a series of clinical lectures on all subjects of ophthalmology, which he intends to treat in the manner of Volkmann's and Seguin's clinical lectures. They will be exhaustive, so that the specialist may read them with advantage, yet so

elementary that the student of medicine and general practitioner can understand them. The specimen number before us treats of the etiology and pathology of the sympathetic affections of the eye. An anatomical sketch of the ciliary body, iris, the cavities adjacent to the iris, and the ciliary nerves introduces the student in a very happy way into the pathology of this region, which prevalently is the seat of the sympathetic diseases. He first speaks of the numerous affections which have been seen or supposed to produce sympathetic ophthalmia in the fellow-eye. Though the descriptions are chiefly original, drawn from the writer's personal experience, he gives an extensive critical review of the literature on the subject. In vain, we are sorry to say, we looked for the name of *McKenzie*, the first author on sympathetic ophthalmia.

The first part of the paper, pp. 1 to 32, gives a very clear and full picture of the etiology of sympathetic ophthalmia, but does not seem to contain anything essentially new. The second part, pp. 33 to 58, describes in detail all the symptoms of sympathetic ophthalmia. The beginning of the *sympathetic irritation* M. is inclined to place into the retina, since photophobia, photopsia, asthenopia, periodic obscurations of the visual field, anæsthesia of the retina with concentric limitation of F. (stenopsia without physical changes, Schilling), are its prevalent symptoms, and frequently precede ciliary neuralgia and blepharospasm.

Among the symptoms of *sympathetic irritation* he mentions : *Keratitis*, superficial vascular, with intense conjunctivitis, periorbital pain, and headache, described by Warlomont. *Intermittent Keratitis* (Rossander). *Irido-Keratitis* (Galezowski, Vignaux, and others). The *inflammation of the uveal tract* is of the greatest importance. Its forms are : *iritis serosa*, prognosis good ; *iritis plastica*, prognosis unfavorable ; *iritis maligna*, *i. e.*, irido-cyclitis plastica, prognosis very bad ; by extension of the process *uvëitis totalis*, *i. e.*, irido-cyclo-choroiditis, the worst of all.

As a remarkable symptom of sympathic irido-cyclitis, M. mentions the following : If only one point of the ciliary region of the eye primarily affected is painful or more painful than the others, the corresponding point only in the eye sympathetically affected will likewise be painful, or more so than the other points.

Sympathetic choroiditis and retinitis, first described by von Graefe, then by Pooley, Galezowski, Rossander, and others, may be either a complication of iritis and cyclitis, or independent of them. The occurrence of sympathetic glaucoma is denied. Some modern operations, linear extraction, irido-desis, and the drainage of the eye (de Wecker), have been the cause of sympathetic ophthalmia.

If the following numbers of these lectures do not fall short of the first —and we do not see why they should—, we may safely predict for them a good deal of popularity, for they are nicely gotten up, and their style is easy, animated, and entertaining—somewhat in the manner of modern magazine literature. They are sure to afford, both to the specialist and the progressive general practitioner, enjoyment as well as information.

K.

10. *Alfred Graefe*, among other preliminary remarks, says (p. 235): If antiseptic treatment has the virtue of obviating in a wound not only the fatal *decomposition* of pus, but also its *formation*, we must infer that the formation of pus is occasioned by exotic germs, and consequently the first act of septic disease. He adds, however (note on page 236), that the question whether, besides the septic, we have to admit an aseptic suppuration or not, is not yet settled. A full introduction of Lister's method into eye surgery seems impracticable. After many experiments, the author has tried, without modification, the following plan on 114 extractions. All complications that may contain septic substances, for instance, lachrymal and conjunctival diseases, are first removed as much as possible. The day before the operation, one drop of a one-per-cent solution of atropia is instilled, and shortly before the operation the conjunctival sack is gently swabbed with a two-per-cent solution of carbolic acid. At the same time the lids and the whole orbital region are cleansed in like manner, and a sponge, moistened with the same liquid, is applied to the closed eyelids until the operation begins. Before and after each operation, the instruments are steeped in absolute alcohol, and wiped with clean soft linen. All cleansing during the operation is done with sponges dipped in a two-per-cent solution of carbolic acid, to replace the spray which Gr. thinks too troublesome and exciting for the patient. Atropine is instilled once or twice during the cleansing of the eye, which is done most carefully. The moment the sponge is taken away, a piece of borated lint is placed upon the eye and the whole orbital region, immediately saturated with a four-per-cent solution of boric acid, and covered, beyond its edges, with a piece of finest oil-silk which, immediately before, was also drawn through a solution of boric acid. Then the orbital region is padded with wound wadding, held in position by a bandage of fine elastic flannel.

The dressing is changed every twenty-four hours, except when unusual irritation follows. In this case the eye remains covered only with a piece of carbolized lint, and cold applications are applied for twenty to thirty minutes, during which time a four-per-cent solution of carbolic acid is brushed upon the lint. As soon as the dressing is removed, the sponge, saturated with a solution of boric acid, is placed upon the eyelids, and with it all cleansing is done, without opening the palpebral fissure. Then the antiseptic dressing is applied as before. In this way the eye for a week is as little as possible exposed to the action of septic germs that may be suspended in the air. Atropine is instilled from the third day after the operation.

The author mostly practises the lower section, steadying the globe by Pamard's pique, and, before the expulsion of the lens, removes both the lid-holders and the pique, in order to close the lids immediately after the exit of the cataract. He takes great care to avoid incarceration of the iris in the wound .by pushing the iris back with a blunt probe.

The results of the 114 extractions have been very favorable, more favorable than those of previous operations. There was suppuration of the wound in three cases, two of which were totally lost, the third ended in chronic iritis with periodic hypopyon, and was discharged with about $\frac{2}{200}$. A fourth case, extraction within the unopened capsule with some loss of vitreous, ended in phthisis bulbi from chronic cyclo-hyalitis. Three other cases showed iritis with more or less dense pupillary membranes, and little satisfactory visual results.

The reviewer, on a visit to Halle, was authorized by the writer to add to his report that the recent results of extractions performed and treated in the same manner, have been less favorable than before, showing an inordinate number of disastrous suppurative processes. K.

11. *Hirschberg*, in the discussion of a paper by *Dr. Schöler* on enucleatio bulbi, in the Berlin Medical Society, gives a historical sketch of the operation of dividing the ciliary nerves. It was proposed by *A. von Graefe* in 1866, and executed by *Ed. Meyer*, first in the same year, and frequently afterward, then by *Secondi* and *Lawrence*, both in 1868. The division of the optic nerve for very annoying photopsia and chromatopsia was done by *A. von Graefe* in 1867, and, together with the division of ciliary nerves by *Landesberg*, in 1869. Landesberg's method (described in vol. XV. of Graefe's Arch.) of first dividing the tendon of the internal rectus has been that followed by Schöler and Schweigger. H. thinks that neurotomy for sympathetic affection is indicated in a few

cases only. We have to rely on the enucleation of the globe which he has performed about 150 times without ever seeing it followed by unpleasant consequences. K.

12. *Hirschberg* compiles seventy-seven glaucoma operations from his own practice during the last four years and a half. He followed von Graefe's rules, with a few exceptions, in which he performed sclerotomy according to Wecker. The results on the whole agree well with those published by von Graefe. He gives a tabulary statement of all the cases, so as to enable the reader to draw his own conclusions. Among the seventy-seven eyes there were :

A. *Four of absolute acute inflammatory, primary glaucoma.* One, showing no inconvenience, was left alone ; in the second the pain was removed by puncture of the cornea ; the other two required enucleation. If the fellow-eye is healthy, H. does not venture to perform iridectomy in absolute glaucoma, on account of the danger of inducing glaucoma in the healthy eye. Within twenty-four hours after sclerotomy also, he has noticed the occurrence of glaucoma in the fellow-eye. *Eighteen eyes with acute inflammatory glaucoma.* Seventeen yielded a good result, one was a failure, the patient being unruly, the section went into the cornea, and incarceration of iris took place.

B. *Two eyes with absolute chronic inflammatory glaucoma ;* in one nothing was required, in the other iridectomy was made in both eyes ; since the fellow-eye also suffered from glaucoma. The glaucomatous inflammation was removed.

Ten eyes with chronic inflammatory glaucoma ; in nine iridectomy yielded a permanently satisfactory result, in one a second operation had to be made two years later, vision poor, $\frac{6}{200}$, but stationary (4 yrs.).

C. *Simple primary glaucoma* subdivided as follows :

a) *Thirteen eyes* with Sc. $\geqq \frac{1}{10}$, and F. at least 10° beyond point of fixation. In ten eyes the glaucoma was arrested, in one S. was gradually abolished, in two, the satisfactory result lasted only a year.

b) S. moderate, limit of F. reaching point of fixation.

One eye with gl. simpl. myopicum. Iridectomy, result unfavorable.

c) Sc. and Se. considerably reduced, F. greatly contracted.

Nine eyes ; in four iridectomy with a permanently satisfactory result ; in three eyes the primary result was satisfactory, but the time of observation was too short to judge of its duration ; in two cases, failure.

d) Glaucoma simplex absolutum, including those cases in which S.$\frac{1}{\infty}$, existed for months.

Three eyes; in two the operation preserved S. $\frac{1}{\infty}$, in one a double iridectomy had to be followed by enucleation, on account of pain.

D. Of *seven eyes* with *glaucoma hæmorrhagicum*, only one yielded a satisfactory result.

E. Of *eight eyes* with *secondary glaucoma*, four in the absolute (confirmed) stage were beyond hope; of the others, three retained their small remnant of S., and the last lost it gradually. K.

OTOLOGICAL PART.

SUPPURATIVE OTITIS MEDIA—CARIES OF MASTOID—EROSION OF VEINS AT BASE OF SKULL.—EMBOLIC ABSCESSES OF LUNGS.—PNEUMOTHORAX RIGHT.—DEATH.—AUTOPSY.

By Dr. CORNELIUS WILLIAMS,

Assistant Surgeon at N. Y. Ophthalmic and Aural Institute, Attending Surgeon Outdoor Department Mt. Sinai Hospital, Attending Physician to Northern Dispensary, etc.

During the latter part of December, 1877, Willie Hübner, about six years old, came to Dr. Knapp at the New York Ophthalmic and Aural Infirmary on account of discharge from left ear, and giving the following history. He had suffered for several years from purulent discharge from left ear, with occasional intermissions, when he was free from any sign of the disease. On one occasion, there had been swelling with great pain and tenderness behind the ear, for which an incision had been made by a surgeon.

The present attack began about three weeks ago, with pain in the ear, fever, and was followed by discharge of matter from external meatus. An examination disclosed a fluctuating swelling behind the ear which was opened, and about three drachms of thick pus set free. It was then found that a probe could be passed into a cavity within the mastoid and toward the middle ear for eight or ten lines. The membrana tympani was perforated. The patient was then referred to me for further treatment.

The ear was cleansed, as was the abscess cavity, and a tent placed in the latter. Instructions were given to the mother as to the care necessary, and to return again in a couple of days. Sulpho-carbolate of zinc, gr. v.; Alcohol, ʒ i.; Glycerine and water, āā ℥ i. was ordered. To put three drops in the ear three times a day.

The patient was brought back in about a week. The discharge from the ear and from the opening in the mastoid was less, he had had chills followed by sweating. Temp., 102; pulse, 100. Ord. quin., to make warm applications to side of head, and to remain in bed. Jan 5th, 1878, patient has had more chills, but less severe. Temp., 101; pulse, 96; complains of pain in side, and respirations are increased. Auscultation does not enable me to detect any change from normal in chest.

Hyposulphite of soda was ordered gr. vi. every three hours, to have nourishing liquid food, together with a modicum of brandy. Jan. 6th, symptoms same, continue treatment. Jan. 7th, there is no discharge from ear or mastoid; parts dry, hot; distinct râles can be heard over various parts of chest. Respirations, thirty per minute and shallow; tem., 100½; pulse, 110. Jan. 8th and 9th, no increase in severity of disease, treatment same.

Jan. 10th. Respirations, sixty per minute; light moist râles heard all over chest, except right infra-axillary region, where there is tympanitis, metallic tinkle, and amphoric breathing over a space as large as the hand.

Percussion note elsewhere duller than normal, with signs of solidified lung, at base posteriorly and left. Child perfectly conscious, with no sign of meningeal implication. Temp., 100; pulse, 130. Treatment same, with addition of $\frac{1}{48}$ gr. digitalin three times a day.

January 11th.—Area of tympanitic resonance now includes nearly the whole of right chest; other physical signs more pronounced. The ear and the opening in mastoid have remained dry; warm applications have, from time to time, been made to that side of head, and the abscess cavity and external ear carefully syringed. Temp., 100½; pulse, 130–140; respirations, 70 per minute.

January 12th.—Patient died about 6 A.M.

Post-mortem examination, 9 hours after death, assisted by Dr. B. Bettman. Rigor mortis well marked; body but little emaciated; calvarium easily removed; no fluid in the arachnoid, subarachnoid, or ventricular spaces; a sero-sanguinolent fluid welled up at base of brain as the tentorium was detached and cut through; no necrosis of the dura mater or of any part of the inner table of the temporal bone. Because of this and hurry, the sinuses were not carefully examined. Subsequent examination of the piece of the temporal bone sawn out and carried away showed the mastoid portion and cavity of the middle ear to have been converted into a common space, which was filled with a semi-solid caseous mass. This cavity extended anteriorly, and communicated directly with two small veins which emptied into the internal maxillary vein. A bristle or small probe could be made to pass without any force from the external ear or through the opening in the mastoid and made to emerge at the cut end of the internal maxillary, between the temporal and pterygoid muscles. No thrombus of this vein could be discovered. Sections of the brain were made in every direction, without anything abnormal being found.

The lungs were found to be studded with a vast number of small abscesses, ranging in size from a grain of wheat to a hazlenut. Each abscess was surrounded by a zone of solidified lung-tissue, which was not essentially thicker at one part than another.

The pus of the abscesses was thick and creamy, in some cases partly inspissated. There were, perhaps, three times as many in the right lung as in the left, and here some of them were found to have penetrated the pulmonary pleura. The right lung was compressed into a flattened cake, which sank when placed in water. The right pleural space was filled with air and about six fluid ounces of a soft, very white, jelly-like mass of albuminous or fibrinous exudation. In some places a beginning organization was found. It contained no pus or purulent fluid.

The heart, liver, and kidneys were normal; other viscera not examined.

A *few remarks* on the above case may not be out of place. The literature of purulent inflammation of the middle ear for the last fifty years would go to prove that, in those cases having a lethal ending, the fatal result is brought about generally by extension of the morbid processes to the brain, either through the mastoid or through the tegmen tympani, abscess of the brain, meningitis, or phlebitis, with succeeding pyæmia from purulent disorganization of the thrombus being the outcome.

A perusal of the record of the cases published, however, will show that the actual cause of death in very many cases is a matter of uncertainty.

It is assumed that there has been pyæmia when some of its symptoms have been noted, and the patient dies, no post-mortem examination having been obtained. But many of the signs of pyæmia may be present, or rather signs common to pyæmia and other conditions, without there having been really pyæmia in the strict sense of the word.

In this case I think it fair to assume that death was produced by the very extensive implication of the pulmonary tissue by the abscesses and the consequent pneumonia and pneumothorax. It is also more probable that these abscesses were produced by a great number of minute emboli carried into the circulation from the small veins, inflamed by proximity to the carious bone, and before their coats were eroded and actually perforated. None of these emboli were small enough to filter through the pulmonary capillaries, and were all arrested there, producing a circumscribed abscess by mechanical irritation, through inflammation of the walls of the capillaries themselves, the same as would a minute globule of mercury cast into that system from the right heart.

ON THE OPERATIVE TREATMENT OF SUPPURATION OF THE EAR.

By Dr. OSCAR WOLF, Frankfort-on-the-Maine.

Translated by James A. Spalding, M.D., Portland, Me.

(With two woodcuts.)

II.

As, in the first part of this paper (Archives, vol v., p. 94, etc.) I discussed the causes of those otorrhœas which resisted all methods of treatment hitherto used, and then pointed out that the seat of the suppuration, at more or less deeply lying and hidden parts of the acoustic apparatus, depended upon processes of adhesion or granulating growths, with or without necrosis or caries of the underlying bony parts, in order then to recommend to my fellow-practitioners the operative treatment by means of the scar-loosener, or sharp spoon therein described; so now I am saved the trouble of proving in the following pages in detail that the method described is easy and safe to practise; that, in a series of cases since the time of the first publication, it has proved itself of benefit, as well by an improvement of the hearing, as through removal of the disagreeable and oftentimes dangerous discharge, as well as of the attacks of dizziness due to the pressure of exuberant granulations, and of the subjective noises, and that the suspicions expressed by a critic, as regards eventual damage of the sound-conducting apparatus, either physiologically or acoustically, are ungrounded.

Since I have had opportunity of watching a majority of the cases in question for a long period, and often through many years, I may be allowed some judgment as regards the frequency and form of possible relapses, and as to the final healing of the formerly carious bony parts.

Following the anatomical arrangement of the parts, I begin with those otorrhœas which have their seat in the external auditory meatus.

As mentioned (l. c.), I found as a frequent cause of the formation of granulations in the external auditory meatus, deeply burrowing furuncles, chiefly at the edge of the bony portion, in which (owing to the great pressure, and extremely trifling yielding of the cuticular lining of the auditory meatus, probably also with the destruction of the subcutaneous connective tissue) the periosteum is also destroyed, whereupon, as a result of disturbances of nutrition, small, circumscribed particles of bone necrose, and they, overgrown with granulations, in their turn keep the whole region in a chronic inflammatory state.

Such cases usually begin with considerable and painful swelling of the auditory meatus, which renders a diagnosis of the seat of the disease very difficult. When, by *avoiding* the usual ear lotions, a lessening of the swelling has been gained by careful cleansing of the ear, and by the use of rolls of charpie, then we may recognize, chiefly at the beginning of the bony part of the auditory meatus, granulations as large as a pin's head or a pea. In the act of digging these out with the sharp spoon, we often notice a distinct grating, and the contents of the spoon show small, black particles of bone.

In the cases in which such circumscribed necrosed parts are simply the result of disturbances of circulation, due to pressure from furuncles, or otitis externa diffusa, the simple removal of the necrosed particles of bone is sufficient for the perfect closing up and healing of the affected bone, for in these cases we have to do with an unindented bony surface, especially in otherwise healthy individuals, who suffer from no dyscrasia.

For the sake of brevity, I will take but two examples from a series of cases.

Case I.—Treatment begun June 14th, 1873. Furuncle with frequent relapses. Granulations and necrosed particles of bone at the beginning of the bony auditory meatus. Scraped off with the sharp spoon. Cure.

Miss A. Sch., daugher of my colleague Sch., 21 years old, previously healthy, suffers for a year from furuncles of the right ear. The last eruption, three weeks before, was particularly painful, and an extremely necrosed nucleus of connective tissue had evacuated itself. The auditory meatus still somewhat swollen at the inferior wall of the bony part, and at its anterior portion, a granulation half the size of a pea. Hearing somewhat reduced, low voice 10′. Watch 2″. The granulations were removed by the sharp spoon, and, in so doing, small, black particles of bone were found in the contents of the spoon. A moderate reactive inflammation of the external auditory meatus followed; four days later, lessening of the swelling, and restoration of normal hearing; ten days later, the small wound made by the operation closed up, and a lasting cure was gained, so that up to this time no more furuncles have appeared.

Case II.—Treatment begun Dec. 28th, 1876. J. S., merchant, 31 years old, has suffered for six months from frequently recurring and very painful furuncles of the *left* ear; lately the cerumen has become thinner, and mixed with pus. Hearing distance somewhat reduced. In the external auditory meatus, there are many scales of epidermis, with thinned cerumen and some pus. On the inferior wall, at the beginning of the bony portion of the auditory meatus, there is a granulation the size of a pea, on digging out which, the sharp spoon grates on some rough particles of bone, and the contents of the spoon show some small, black particles of bone. Afterwards the ear is syringed out with a one-half-per-cent solution of carbolic acid* and then closed with small rolls of charpie. No reactive inflammation follows, and nealing of the operated place ensues in eight days. Since then no relapses of furuncles.

After severe *otitis externa diffusa*, the epidermic lining of the external auditory meatus and of the membrana tympani often falls off in toto, and after many such sheddings, there gradually forms between the membrana tympani and the external air a firmly closing plug, behind which granulations and pus originate. In such cases we often see repeated attacks of facial erysipelas, which evidently have their starting point in the granulated and suppurating portion of the auditory meatus. After clearing away the masses of epidermis, and relieving the pressure which they cause as a foreign body, and on account of the unhindered entrance of atmospheric air, the granulations oftentimes shrivel without farther treatment, provided they were not already too compactly organized, and the bony part had remained healthy—or a slight pencilling with a small lump of argenti nit. melted on the end of a silver wire is enough to cause them to shrivel. The three following examples will serve to explain the above-mentioned form of disease.

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* At this point I would mention that, for a year and a half, I have operated antiseptically, in so far as to dip the instruments used into a solution of carbolic acid, to drop some of the same solution into the ear for a few days, and that since this time I have very rarely observed any reactive inflammation of the external auditory meatus after the various operations.

Case III.—Treatment begun Oct. 24th, 1868. Repeated attacks of facial erysipelas due to otitis externa diffusa, with consecutive formation of granulations. Cure.

Miss J. K., 28 years old, from Hanau, of delicate constitution, has suffered for six years with frequently recurring facial erysipelas. All possible precautions against catching cold, courses of baths at Nauheim and in sea-water have been unable to prevent the young lady from being visited every four or six months by the extremely painful affection, visibly affecting her bodily strength. As moreover, during the last six weeks, dizziness, headache, deafness, and tinnitus had come on, I was consulted.

I found the hearing distance reduced: *right*, watch 4″; low voice 12′; *left*, watch on contact; low voice 4′. Some thin pus was found in the moderately swollen and much reddened external auditory meatus (both sides), and at the bottom, some masses of epidermis, firmly wedged in, especially on the *left* side, in fivefold layers, representing, after its somewhat difficult removal, a cast of the auditory meatus. When this had been done, the grievous symptoms stopped, tinnitus and deafness were removed; but the auditory meatus (both sides) remained furrowed, and secreted some pus, the cause of which I was then unable to recognize, since the visible portion of the membrana tympani looked simply tarnished, but without any perforation. The air douche gave only the usual sound of the air striking against the memb. tymp. A year and a half later, I saw the patient again. Until within a few days she had been spared from erysipelas, but now the beginning symptoms of that disease had appeared. The erysipelas wanders over the forehead and bridge of the nose to the left side of the head. When the swelling of the parts had lessened, a considerable mass of epidermis was again removed from the right ear, and small granulations were seen near the annulus tympanicus, at the anterior wall of the external auditory meatus. In the *left* ear I found granulations at about the same spot, but there was less shedding of epidermis, and it was less compact. The growths disappeared after many repeated cauterizations with the silver wire tipped with argenti nit.; the purulent secretion gave way to one of a more ceruminous character, the lining membrane of the auditory meatus grew firm, and its sensitiveness lessened, the hearing distance became constant, and the general health, as well as the bodily strength, left nothing more to be wished for from this time forward. In the pretty long series of years since passed, the lady has never again suffered from erysipelas.

CASE IV.—Otitis externa diffusa, with formation of granulations on the processus brevis; spontaneous shrivelling of the granulations.

P. S., a saddler from Frankfort, consulted me on the last of April, 1876. The patient had undergone many violent inflammations of the right ear for several months without seeking help, and it was only through a suddenly occurring attack of extreme deafness, with intense tinnitus, a few days before, that he had been induced to take advice. The hearing distance on both sides was very much lessened; whispers not understood, loud voice at not more than 10′ distant; watch on contact, both sides. The right auditory meatus, reddened and slightly swollen, contains many coarse masses of epidermis, covered with cerumen. After instillation of a solution of soda, I succeeded in loosening the mass, composed of about eight layers, by means of a sound, and then in extracting it. A granulation about $\frac{1}{3}$ the size of a pea appeared on the processus brevis of the somewhat furrowed membrana tympani. This shrivelled very rapidly during the next few days without medication, and in ten days the membrana tympani showed its normal brilliant tint. A coarse plug of cerumen had been the cause of the disturbance of hearing in the left ear.

CASE V.—Otitis externa diffusa with periparotitis; collapse during chloroform-narcosis. Foreign body pried out by means of the sharp spoon. Treatment of the subsequent periostitic obliteration of the bony portion. Cure.

J. W., 6½ years old, previously well, came under my care April 10th, 1876.

The attack had begun four weeks before with feverishness, pain, and swelling of the whole neighborhood of the left ear and parotid gland, from which cause the physician in charge diagnosed it as an epidemic periparotitis. Later, a purulent flow from the left ear had set in, to stop which various astringent ear lotions, and lastly solutions of argenti nitras, had been instilled, but without success. At my first examination, the cartilage of the ear and the auditory meatus were of such a uniform black tinge that I could not accurately distinguish the regions in question; but it seemed to me as if some sort of foreign body lay in the depths of the auditory meatus. The hearing distance was very slight; 4′ loud voice—ticking of watch not heard. After the ear had been carefully cleansed with luke-warm water for two days, I distinguished the foreign body, by the lamellar structure of its cut surface, as the half of a large bean, which rested, firmly wedged, in the bony portion, and seemed already entirely surrounded by slightly bleeding granulations.

The removal of the bean was made very difficult by various circumstances; it did not move nor shake when syringed with a powerful stream; pincers would only break off minute particles, the granulations would bleed and hide the field of vision, and above all, the boy was so irritable that he could not be forced to keep still. Longer waiting being precluded by the danger of retention of pus, and on account of the headaches already present, I decided to go behind the foreign body with a sharp spoon, while the patient was under chloroform, and then to lift it out from the auditory meatus. With the assistance of Surgeon W., the narcosis was undertaken with all due precautions. The boy lay in a semi-recumbent position, at first boldly opposed the chloroform, but just as I was on the point of introducing the sharp spoon, I noticed that he rapidly collapsed—it was a frightful moment. It was only with difficulty that I succeeded in jamming open the convulsively closed lower jaw, in drawing forward the tongue with the hooked forceps, and after removal of the mucus on the epiglottis, in bringing on regular respiration. But it was not until at least half an hour later, that the powerless state into which the boy repeatedly relapsed gave way to a more powerful activity of the heart, under the action of strong irritants. In the evening I found the patient well again; then I first learned from his mother that he had coughed a great deal during the night before, and then I confirmed the presence of a slight bronchial catarrh, which in all probability, together with its hindrance to respiration, had been the cause of the unfavorable accident. A few days later I succeeded in making the boy hold still, by threatening him, and *then going behind the bean with a sharp spoon, I pried it out with a quick and powerful motion.*

The hearing distance instantly increased to low voice 20′. The bony auditory meatus was already considerably narrowed by periostitis, and now came on the rare event* of the irritation developing a tendency toward a perfect cicatricial and cuticular obliteration of the auditory meatus, and that in spite of the removal of the foreign body, and in a boy afflicted with no dyscrasia. Energetic destruction of the successive growth of granulations with the usual caustic did not prevent a repeated temporary cutaneous closure of the auditory meatus. Even the insertion of laminaria remained unsuccessful in this period, for it was repeatedly pushed aside, and pressed out from the obliterating spots, by the swelling of the periosteum. In this way, the hearing distance was again extremely lessened.

After this condition had lasted fourteen days, and the cauterizations remained unsuccessful, I entered with the sharp spoon, came upon a rough patch of bone on the inferior wall; hereupon a small plate of bone at once fell off; probably this had kept up the swelling of the periosteum, for under simultaneous repeated introduction of rolled strips of sticking plaster, renewed every two days by a fresh bit, we now succeeded in keeping the passage of the auditory meatus open. The swelling of the periosteum disappeared, the granulations shrivelled spontaneously, and a perfect cure was gained after a course of treatment lasting six weeks in all.

When, in our consideration of the diseases now in question, we pass from the more exterior to the deeper seated forms, we next meet with those cases of *purulent inflammation of the middle ear* in which the exuberating granulations forming in the region of the gap in the membrana tympani lie hinderingly in the way of the closing up and healing of the membrana tympani. Since the *anterior inferior quadrant* of the membrana tympani is preponderatingly the seat of perforations, we find the base of these granulations at the inferior wall of the tympanum by preference, or in the sometimes pretty narrow angle which the membrana tympani forms with the inferior wall of the auditory meatus. In a narrow auditory meatus, and one curved anteriorly and inferiorly, even after the swelling has lessened, there is need of a very careful cleansing of the parts from the lamellæ of epidermis now and then covering them. For this I use by preference a fine sound, in order to confirm the presence of granulations and to remove them at once with the sharp spoon. Naturally, such an operation can only be well done by favorable daylight. If, on cutting the granulations out, we come upon patches of rough bone, which are often found at the annulus tympanicus, then we may scrape them off less roughly, because here we have to do with no bony districts of importance, either physiologically or acoustically, the wounding of which would be different. Moreover, the bone at this region is almost always merely superficially eroded, and it is rare that more than two such operations, of course with a pause of several days, are needed; we must also watch carefully any possible formation of scars before we decide to repeat the operation.

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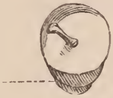
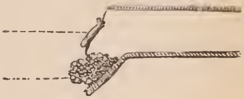
* In the literature accessible to me, I find no analogous case described, up to this date.

Case VI.—Accumulation of epidermis in the bony portion of the auditory canal. Otitis media. Patch of carious bone with granulations springing from the anterior lower quadrant and extending to the floor of the tympanic cavity. Cure after six weeks' treatment.

Mary M., æt. 33, cook from Hanau, had suffered several months from noises in her ears and hardness of hearing. One week before she consulted me, January 10th, 1877, she began to complain of intense headache, earache, and dizziness. The hearing distance measured 6′ for loud voice; ticking of watch was not heard. The left external auditory canal was much swollen and contained anteriorly a small quantity of cerumen; the bony portion was completely filled with tenacious, fetid epidermoidal accumulations. When the swelling had subsided, I succeeded with some difficulty in loosening the scales, and removing them with the forceps. The patient felt better immediately; the noise, headache, and dizziness disappeared. The membrana tympani appeared reddened and swollen. Upon applying the air douche, distinct râles were heard in the tympanic cavity, no perforation whistle. The hearing distance increased to 10′ for whispering voice. Ten days later, the secretion of pus was still profuse and fetid, though the drum-head had begun to clear up. I then discovered that the suppuration proceeded from a mass of granulations springing from a niche situated at the edge of the annulus tympanicus and extending to the floor of the tympanic cavity. The lower segment of the annulus tympanicus had a notched appearance. On account of the angular course of the bony portion of the auditory canal, the above-mentioned niche could be reached only with difficulty. I finally succeeded by directing the cutting surface of the sharp spoon decidedly downward. After scraping away the granulation mass filling the depression, I found black particles of bone in the contents of the spoon. After the operation, the air passed whistling through the tympanic cavity, and the hearing distance was increased to 22′ for the whispering voice, and 8″ for the ticking of the watch. The patient returned after twelve days. Upon examination, I found the seat of operation covered with thick pus, and the depression filled again with granulations. I removed the latter in two sittings at intervals of five days. The second time I could not discover any rough bone. In the course of a few days, the drumhead became perfectly normal as regards its lustre and tension; the light spot reappeared and the hearing distance increased.

Twelve days later, and the end of February, the seat of operation showed a crescent-shaped white cicatrix measuring 5 mm. in width, and 3 mm. in height, and extending downward from the lower limiting line of the membrana tympani. The two accompanying cuts illustrate these conditions sufficiently.





It is possible that in the beginning the case was one of suppurative subacute otitis, which was followed by otitis externa, consequent upon necrosis of a small portion of bone at the floor of the tympanic cavity and at the edge of the annulus tympanicus. This otitis externa, with its large deposits of epidermis, may have caused pressure upon the membra tympani and all the grievous symptoms.

Case VII.—Purulent inflammation of middle ear; granulations in the anterior inferior quadrant. Cure by formation of a scar after eight weeks' treatment.

Madame G., 30 years old, a delicate woman, came under treatment Nov. 5th, 1876. She had noticed for several months a varying deafness of the right ear; within three weeks more acute symptoms, such as pain, tinnitus, discharge from the ear, and heavy feeling in the head, had come on. The hearing distance was 3″ for the ticking of a watch, 8′ for whispered words. The external auditory meatus seemed swollen by inflammation, the membrana tympani softened and bluish-red, partly covered with purulent secretion, its anterior inferior portion invisible on account of the swelling of the auditory meatus. On using Politzer's air douche, the air passed through hissingly, with relief. After eight days' treatment by the above-mentioned method, the swelling had lessened so much that a small perforation in the anterior inferior quadrant, and below it a granulation the size of a pea, could be recognized. Cauterization next followed by means of the silver wire tipped with argenti nitras. A very painful inflammation of the auditory meatus, the external ear, and its whole anterior neighborhood, accompanied with fever and a noticeable falling off in bodily health, now followed, which reduced in an extreme degree the strength of the delicate woman. When this inflammation stopped, the granulations, which had grown in the mean while, were cut off with the sharp spoon (on account of the narrowness of the auditory meatus, it was hard to reach the base of the granulations with the spoon), but they grew again in a few days and had to be removed a second time; in doing which a few small, black particles of bone appeared in the contents of the spoon. No inflammatory reaction followed the operation; the perforation healed up, and the hearing distance increased to the normal standard.

CASE VIII.—Purulent inflammation of the middle ear, granulations, and spots of carious bone in the region of the anterior inferior quadrant.* Cure after four weeks' treatment.

H. A., tailor, from Edenkoben, 27 years old, pale and slender, otherwise well by his account, began treatment November 10th, 1876. He had noticed some purulent secretion in the *right* ear for several weeks; within eight days, violent pains, tinnitus, and a high degree of deafness had come on. He could not hear the watch at the external auditory meatus, nor when applied to the temple, loud words were understood only quite close to the ear. There was a purulent, offensive secretion in the much swollen auditory meatus; the posterior portion of the membrana tympani was livid. On using the air douche, a rattling entrance of air was gained with difficulty, but the patient at once felt relieved, and hearing distance increased to: watch on contact, low voice 2′, loud voice 15′. Ordered two leeches over the mastoid process, mineral waters, daily air douche by means of catheter.

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* For the sake of brevity, in the following cases, I shall use the division of the membrana tympani in such a way as to divide the field of operation into four quadrants, and then comprehend the bony district lying at the periphery of each quadrant under the term "quadrant."

Eight days later, the auditory meatus was so much less swollen that we could recognize in the anterior inferior quadrant a granulated mass, the size of a lentil; on removing this by the sharp spoon, it seemed to have sprung from in front of a carious spot, which stretched away into the inferior wall of the tympanum; then, on using Politzer's method, the air hissed freely through the gap in the membrana tympani. Syringing with a solution of carbolic acid; no inflammatory reaction. The carious spot of bone had twice to be scraped roughly, then it healed, and after four weeks' treatment, the conditions of the tympanic apparatus were again substantially normal.

Case IX.—Purulent catarrh of middle ear, right side, with formation of granulations on carious bone in the anterior inferior quadrant. Cure after six weeks' treatment. Chronic catarrh of left Eustachian tube.

G. K., 41 years old, a well-nourished butcher of Frankfort, came under treatment Oct. 2d, 1876. He had frequently suffered in childhood from ear-aches and varying degrees of deafness, but in manhood his hearing had become pretty fair. After an influenza he had noticeable deafness on both sides for two weeks. Right side, violent pain, tinnitus, and purulent discharge. Hearing distance: Right, ½″ watch; whispered words not heard; loud voice not heard beyond 10′. Left, watch 1″; loud voice 12′.

Right membrana tympani drawn in; in the anterior inferior quadrant a perforation with an overlying granulation which springs from a carious base; the air douche produces a hissing sound with difficulty. Single scraping of the diseased bony part; instillation of solution of carbolic acid. No farther inflammatory reaction. Closing up and lasting readjustment of the membrana tympani after six weeks. Hearing distance for watch 8″, low voice 28′.

The nose was narrow, its mucous membrane much relaxed, and as nearer examination showed, there were granulations at the opening of the tube. Ordered: nasal douche with luke-warm water and milk, pencilling of the nose, now and then, with argenti nitras, glycerin solution. Blowing of pulv. alum into the naso-pharyngeal space. Under this medication and with help of Politzer's method, the *left* ear also improved, so that the hearing distance at the close of treatment was, 10″ watch, 34′ low voice, and has since remained pretty constant.

CASE X.—Acute purulent inflammation of the middle ear. Granulations in the anterior inferior quadrant. Relative healing after five weeks' treatment.

F. T., 24 years old, a merchant of Havre, came to me April 4th, 1876, on account of a painful disease of the ear from which he had suffered for eight weeks there. Violent pains in the head and ears, tinnitus and deafness, offensive discharge from the right ear.

When he reached here, the hearing distance was much reduced; watch just heard on contact. Loud voice 10′; low voice not heard. Air was forced into the tympanum with difficulty by Politzer's method. The auditory meatus very much swollen and sensitive; the posterior portion alone of the membrana tympani visible as a bluish-red surface. After a treatment of twelve days, a granulation as large as a small pea showed itself in the anterior inferior quadrant of the membrana tympani, which was cut out by the sharp spoon from the edge of the perforation; no inflammatory reaction followed the instillation of the carbolic acid. The suppuration lessened at once, the secretion became more viscous, serous, stringy, and after five weeks' treatment the membrana tympani was clear, but a perforation a little larger than a pin's head remained. I saw the patient again on the last of December; the perforation was still present, but in the auditory meatus there was a ceruminal secretion; the hearing remained constant—6″ watch; 20′ low voice.

Next to the *anterior inferior* quadrant, in which most perforations are observed, there is also another favorite spot for granulating growths, viz., the district of Shrapnell's membrane, or that segment of the outer wall of the tympanum where the membrana propria is wanting; possibly the slighter resistance of the membrane against the pressure of the column of air, thereby postulated, is the reason why it is relatively more often destroyed at this spot. Besides this, the posterior pouch of Tröltsch, at the inner side, favors a longer retention of pus, and therewith erosions and caries of the neighboring bone. A very noticeable percentage of the operations concerned the posterior superior quadrant toward the region of the posterior pouch of Tröltsch.

Many structures of quite important dignity are here brought into account, at first, the chorda tympani, which is sometimes destroyed by the suppurative process itself, although it offers porportionally a remarkable and longer resistance than even the bone. On operating with the sharp spoon in this region, in cases X., XI., XIV., XV., an irritation of this nerve was caused, so that alterations in the sense of taste could be observed, for longer or shorter time, in the anterior third of the tongue, to which this nerve is distributed. I have never yet noticed a lasting unilateral weakening of taste at the point of the tongue, in any cases operated upon.

Moreover, the preservation of keen taste does not seem to me as anything, in comparison with the danger of a deeply burrowing suppuration of bone; I shall therefore not be afraid of utterly destroying the chorda, when I have in view the healing of the ulceration of bone in question, by means of deep scraping.

If we go behind the processus brevis of the malleus with the sharp spoon, and above it and slightly deeper, then we strike, beneath the path of the chorda, or even through it, the long arm of the incus; farther upward we might touch the articulation of the malleus and incus, presupposing the outer bony wall of the tympanum defective; here also care is ordered, and we should only scrape superficially. In another series of cases, the diseased bony patches lie more towards or even in the *posterior inferior* quadrant; here in a posterior direction we touch the mastoid cells, which can be scraped roughly without harm.

The following cases of operations, which concern the *posterior superior*, as well as *posterior inferior* quadrant, will serve to explain more closely what has just been said.

The district of the *anterior* superior quadrant, of which I bring no examples, is fortunately that bony portion of the outer tympanic wall least frequently attacked by caries; were this not so, our statistics of ear diseases resulting in death would be far more unfavorable than it already is; for the plate of bone separating this section of the bony auditory meatus and anterior superior portion of the tympanum from the dura mater is here most slightly developed, indeed it sometimes stands in direct union with the membrane of the brain, by vessels running through fissures in the bone. When I find granulations in this region, I content myself with their simple removal, but should not decide to act energetically upon the bone itself, with the sharp spoon.

When there is a large defect in the membrana tympani, we can see, as is well known, the corresponding portion of the inner or *labyrinthine* wall of the tympanum widely exposed. The mucous membrane on the promontorium is found furrowed and covered with fine granulations; sometimes larger, more polypus-like granulations are developed. *Caries* of this portion of bone does not often come under observation, for, on the one hand, the substance of this bone is very firm and resisting, and, on the other hand, its circulation of blood is less influenced by pressure from exudations than at the outer tympanic wall. On the contrary, cases of caries of the head of the stapes, and even of both of its arms, are more often mentioned—a fact which explains itself by the easier caused disturbances of nutrition in this small bone, when the circulation of blood is interrupted.

The relaxed and finely granulated mucous membrane of the labyrinthine wall, due to neglected suppuration, diminishes quickest when treated with strongly concentrated luke-warm solutions of argenti nit., neutralized directly afterward by common salt.

Case XI.—Purulent inflammation of middle ear on both sides, during the measles. Pleuritis. Development of a scrofulous dyscrasia. Right, caries in posterior superior quadrant. Repeated recurrence of granulatory growths. Relative cure. Time of observation, 5½ years.

L. B., 6 years old, had a severe attack of measles at Baden-Baden, in June, 1871. Even before the outbreak of the exanthem, pain came on in both ears after a stoppage of the nose, followed by a purulent secretion, with extreme deafness. Towards the end of the fourth week of the measles, pleuritis supervened (possibly due to the resorption of pus from the tympanum), which not only dangerously threatened life, but so deteriorated the development of the child, that during convalescence a scrofulous dyscrasia unfolded itself. I found, at my first examination in December, 1871, six months after the beginning of the attack, chronic swelling of the nasal mucous membrane, of the glands of the neck and throat, periostitic swelling of the bony auditory meatus on both sides, and of the middle phalanx of the right middle finger.

When the swelling of the *right* inferior auditory meatus was somewhat less, the membrana tympani seemed thickened and relaxed; there was a perforation as large as a lentil in the anterior inferior quadrant, and a granulation half as large as a pea in the posterior superior quadrant at the annulus tympanicus. Hearing distance very slight: watch on contact; loud voice 6′.

Left ear, the deeper parts were hidden from sight for a long time by the swelling of the auditory meatus. Hearing distance very slight: loud voice 2′, watch weak on contact.

An examination of the organs of the chest showed to the right and behind the scapula, and up to its angle, dulness and pleuritic friction sounds.

Course and treatment: Strengthening remedies were at once used, and Politzer's method, and later, various solutions of lead, zinc, and argenti nit. were instilled. *Right*, the lining of the tympanum gradually lessening in swelling, the secretion became more mucous, but the perforation and the granulation remained unaltered. Hearing distance increased; watch 2′, loud voice 20′, whispered voice 3′.

The swelling of the periosteum lessened very gradually, *left;* by March, 1872, a coarse polypus as large as a pea was seen at the bottom of the auditory meatus. But at the same time, attacks of dizziness and vomiting came on, which induced the anxious parents to allow the operation for removal of the polypus springing from the inferior wall of the tympanum. When the polypus had been crushed off, the symptoms of pressure disappeared, vomiting and dizziness did not return, suppuration lessened, but the hearing distance did not decidedly increase, because the lining of the tympanum remained in a state of chronic inflammatory hypertrophy, so that the air only entered rarely and with difficulty on using the air douche. The granulation, *right*, was cauterized in the following weeks with argenti nit. in substance; the mucous membrane, *left*, with a concentrated solution. In May, a swelling of the periosteum on the mastoid process came on with feverish chills which, however, retreated after using warm cataplasms. Iodine and cod-liver oil were given abundantly without causing absorption of the scrofulous hyperplasia on the middle finger ; but the pleuritic friction râles, and dulness about the scapula disappeared, and the general health improved. Toward the end of the summer of 1873, a relative cure came on in so far that the granulation, *right*, shrivelled after repeated energetic cauterizations, the membrana tympani cleared up, the mucous membrane of the tympanum, visible through the gap, appeared more yellowish-red, and cerumen spread over the auditory meatus. Hearing distance : low voice 15′, watch 6′. Exuberant growths could not be prevented in the *left* ear, and a larger scar formed in the anterior inferior quadrant. Hearing distance still slight : loud voice 6′. Tinnitus was never complained of. About this time, too, the hyperplasia on the middle finger grew smaller, the first phalangeal joint became movable, and the finger regained its normal contour.

In reaching this result, so favorable on the whole, a prolonged sojourn in the mountains and saline baths of Berchtesgaden were certainly not uninfluential. The condition did not change, and during 1874 and '75 the boy had coryza with slightly more mucous secretion, and slightly less hearing distance of the *right* ear ; this improved again after using Politzer's method ; he went to college and made pleasant progress.

But in February, 1876, in union with renewed scrofulous swelling of the glands of the neck and throat, there came on some symptoms of the *right* ear, which kept me for a long time in great anxiety, not only on account of the threatened hearing, but even of the life of the promising boy. A spongy granulation, with greatly increased offensive secretion, grew in the course of a few days at the former mentioned spot in the posterior superior quadrant, down over the posterior half of the membrana tympani, and reduced the hearing so much that loud words could be heard at only 4′. The danger that the unhealthy pus would dissolve the rest of the membrana tympani was near at hand.

I therefore, when the patient was under the influence of chloroform, cut off the granulating mass, but noticed that it did not grow smoothly from the rim of the membrana tympani, but from a hole in the bone as large as a pea, which, also filled with granulations, stretched inwards towards the chorda and backwards toward the mastoid cells. I therefore scraped it out at once, and found numerous black, necrosed particles of bone in the contents of the spoon. The patient felt very comfortable after the operation, and perceived nothing but the characteristic alteration of taste due to the irritation of the chorda. The hearing distance at once reached its former amount: 15′ low voice. No inflammatory reaction followed the instillation of carbolic acid.

But just three weeks later, the growth started anew, grew very fast, and was again removed as before, and again there were black particles of bone in the spoon after scraping the hole in the bone. I grew anxious with the idea that the rapid second growth of the granulation was to be looked at as a symptom of progressive caries; and that this might attack, anteriorly and superiorly, the tegmen tympani, destroy the bone, and affect the dura mater. Fortunately, the patient showed no symptoms of any irritation of the brain. And thus, renewed growth of the granulation and the operation of scraping out, always under chloroform, the hole in the bone, succeeded each other, four times in all, from March to May, 1876; at last no more necrosed particles came off by the spoon, and the wound closed over. The swelling of the glands also disappeared under use of cod-liver oil and salt-baths. A longer sojourn in the mountains and sea baths at Blankenberge caused such an improvement in his constitution that Louis B. is now blooming and healthy, and able to keep a good place in the second class of the college; for his hearing, *right*, is 15′ low voice; 8″ watch. The adhesions in the *left* tympanum will not allow an improvement of hearing beyond loud voice 6′.

CASE XII.—Acute purulent inflammation of right middle ear. Granulations in tympanum removed with the sharp spoon. Cure after seven weeks' treatment. Disease of *left* middle ear three months later. Paracentesis of membrana tympani. Cure after five weeks. Time under observation, one year and a half.

E. H., valet, 34 years old, pretty well nourished, pale face, occasional cough and plegm, but never having any disease of his ears, was seized, while travelling, about the middle of Oct., 1875, with intense pain, tinnitus, deafness, and suppuration of the *right* ear. He returned to this place in the third week after the attack, and when he came under my charge, there were already extensive alterations present. In the right external auditory meatus, which was swollen, there was a great deal of offensive secretion, the membrana tympani relaxed, livid, its posterior half *curved forward*, and granulations sprang from the perforation occupying the middle third of the posterior half. The air hisses through with difficulty on using the air douche. At the same time the general state of the patient was very bad; he was worn out by furious pains at night, feverishness, irritating cough and loss of appetite, and then came on an attack of dizziness, proably due to the pressure of granulations on the membrane of the fenestra rotunda. Examination of the chest showed an extensive râle, but no dullness, in various districts; there were strong suspicions of beginning phthisis. Hearing distance very slight; watch 0, loud voice not more than 6′.

As the patient's state was not improved after fourteen days' use of the air douche and various astringents, and even a concentrated solution of argenti nit., I decided to operate; taking the sharp spoon, I first cut off the rather coarse growths springing forward through the perforation, penetrated then into the tympanum, turned the spoon upward, cleared out the rest of the granulations towards the posterior pouch of Tröltsch, and reached, in the direction of the mastoid cells, a patch of rough bone which I scraped out. Then a careful cleansing with carbolic acid solution.* After the operation, the patient felt very much relieved, the dizziness and the fearful ache in the head spreading out towards the crown, as also the tinnitus, disappeared; on the other hand, he perceived the characteristic alteration of taste due to irritation of the chorda, which, however, disappeared in a fortnight. On the next day, the hearing distance was: 10′, low voice. Ten days later, a granulation, half the size of a pea, growing forward from the inferior edge of the perforation, was properly crushed off. The secretion thereupon became viscid, the membrana tympani began to clear, the gap closed. By the end of December, ten weeks after beginning of attack, the membrana tympani had already regained its lustre, and showed nothing abnormal but a linear, white scar at the place of operation. The hearing distance was somewhat weakened in contrast with the normal; watch 2″, low voice 25′; and a slight hissing tinnitus continued. The bodily powers were noticeably increased, and an examination of the lungs showed them to be in good order.

Three months later, the hitherto healthy *left* ear became affected by exposure to a raw north-east wind, with symptoms of acute inflammation of the middle ear. As on the 21st of March, the posterior part of the membrana tympani seemed much curved forwards, paracentesis was done, and a moderate amount of serous, viscid fluid was driven out by Politzer's method.

The inflammation ran a much milder course than that of the right ear, thanks to therapeutic management begun at the right time. There was no formation of granulations, and the cure was completed in four weeks. Up to this time, a year and a half from the first attack, E. H. has been well, and the only thing noticeable is the slight resistance of the mucous membrane of the respiratory tract against harsh weather. The slightly lessened hearing distance, and the hissing tinnitus, probably due to some thickened spots in the lining of the tympanum, are unchanged.

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* I remind my readers, once for all, that syringings after operations are very painful; we should only rinse out very cautiously.

Since from the above-described case we have gained proof that we can penetrate with the sharp spoon *through the opening of a perforation*, towards the posterior section of the tympanum, and, without risking any subsequent disturbance of function, can clear out the growths therein recognized, indeed must clear them out unless we will allow the formation of adhesions, which, when contracting, will lead to high degrees of disturbance of hearing, so now, the two following cases prove that the relatively normal membrana tympani can be incised, and the growths in the tympanum, recognized by means of the sound, can be removed therefrom by the sharp spoon, without running the risk of a subsequent reactive inflammation.

Case XIII.—Variola vera, with otitis media, both sides. Removal of epithelial growths from the right tympanum. Cure after eight weeks' treatment.

J. K., 62 years old, a baker from the Wetterau, fell ill of variola vera in the middle of February, 1876. Towards the end of the second week of the attack he felt heaviness and pain, with violent knocking tinnitus (like threshing) in both ears. Later, some moist secretion came on, but no real suppuration, and at the same time the deafness increased quite gradually. The constitutional disease ran a moderately severe course, the eruption of pustules was thickest in the face and on the head, and owing to its confluent nature, a facial erysipelas came on in third week of the attack. Convalescence began only towards the sixth week.

On May 16th, ten weeks after the beginning of the ear affection, I found the following condition at my first examination: in the face, numerous small-pox scars, moderately pigmented, and pretty closely crowded, but only a few on the external ear and in the external auditory meatus.

Right ear.—There is a large amount of epidermic scales, mingled with secretion, in the external auditory meatus which is still swollen in its bony portion. The membrana tympani is not clearly to be seen. The auditory meatus, extremely reddened deeper in, passes over uninterruptedly into a hemispherical mass, curved forward, reddish-brown in color, flushed, and shining like jelly, and which seems to occupy the whole space of the posterior half of the membrana tympani. Hearing: watch 0; loud voice only at 1′. The air from the douche enters only with difficulty, with a very perceptible rustling, but immediately afterwards the hearing improves; whispered voice, 2′; loud voice, 12′.

Left ear.—Scales of epidermis, mingled with secretion, in the much swollen and reddened auditory meatus; the membrana tympani, which is drawn inward, shows a more distinct contour than that of the right ear, but it is extremely puffed up and thickened, so that the handle of the malleus cannot be seen. Hearing distances: loud voice, 4′, watch on contact. Somewhat difficult entrance of air with rustling on using the air douche, but the hearing is at once improved; loud voice, 12′.

The patient was much relieved by the use of the air douche; "he now feels his head again!" Tinnitus also grew weaker, and the mental disposition, which on account of the great pain in the ear had been despondent, improved.

Course: as the hearing of the *right* ear did not improve any farther after using the catheter for ten days, and as the peculiar bulging of the posterior portion of the membrana tympani (which, owing to decrease of swelling of the auditory meatus, could now be more clearly recognized as the membrana tympani, and the corresponding part of the tympanum) still remained constant, I first made an exploratory puncture into the growth; only one drop of blood escaped; the configuration of the curvature remained as before. A few days later, I decided to operate with the sharp spoon. First of all I made an incision into the bulging portion of the membrana tympani, then entered the tympanum with the sharp spoon, and cleared out the jelly-like masses which filled the posterior inferior section of the tympanum. There were no black particles of bone in the hollow of the spoon, but simply the masses which will be more clearly described farther along. The result of the operation was excellent, the hearing rose to, low voice 8′, the air now hissed freely through the tympanum. Instillation of carbolic acid. No inflammatory reaction. Three days later, the contours of the membrana tympani were already more distinct, the handle of the malleus could be seen; the scar began to form in eight days, and the membrana tympani became more gray. After-treatment: air douche, or Politzer's method, every other day. By July the hearing was: watch 4″, low voice 20′, then the membrana tympani cleared up, and at the beginning of August, a white, linear scar could be seen in the now normally glistening membrana tympani, and near the annulus tympanicus.

The *left* ear gradually improved by use of the air douche, the membrana tympani cleared up, the tinnitus disappeared. At the last examination, at the end of October, the hearing of Mr. J. K., considering his advanced age, was quite normal.

Wendt, in his excellent article,* says:

"I found the mucous membrane swollen in a *polypoid fashion*, or *growing exuberantly*, in twenty-nine tympani. Next to an inflammatory swelling, *hyperplastic processes* are to be regarded as the cause of the immoderately great and usually more important increase in volume of single spots, quite evidently at least in those cases distinguished by remarkably moderate formations. As to the *configuration of the upper surface*, it was raised into solid *nodules*, *granules*, *tufts*, *knobs*, or *flaps*, and that at single spots, or in greater extent, or *to excrescences of considerable circumference*.

At another place (page 156), Wendt describes the epithelium in microscopic sections.

"A thickening of the epithelium had arisen from two causes, first by an increase in the number of its elements, second by an *increase in their volume*.

"Perpendicular sections showed three, four, and even more overlying rows of cells, the external of which had preserved the original form of an epithelium, while the rest were swollen into a more or less globular shape, and while giving a dull reflex, yet appeared bright, and held a few pus corpuscles here and there."

I found precisely the same on a microscopic examination of the masses removed with the sharp spoon; they were made up to a preponderating degree of several layers of overlying and swollen epithelial and fresh connective-tissue cells.

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* "On the Behavior of the Ear and Naso-pharyngeal Space during Variola." Archiv der Heilkunde, 1872, page 153 et seq.

In the *right* tympanum our case had gone on to a formal hyperplasia of epithelium, with beginning organization of connective tissue, while in the *left* tympanum the process had not gone beyond the thickening of the epithelium (visible in the loosened and thickened membrana tympani) and a collection of viscid masses of secretion. The result is to be regarded as extremely favorable, considering the advanced age of the patient.

CASE XIV.—Otitis media chronica, with exuberating granulations without perforation of the membrana tympani. Cure after six weeks' treatment.

Willy W., eight years old, has often suffered, during several years, from pain in the *right* ear, in which some moisture has been occasionally noticed. When he came under charge, his hearing distance was, watch 2′, low voice 6″. There has been occasional tinnitus, but never any dizziness. The posterior portion of the membrana tympani seems reddened, curved forward, much loosened, partially covered with secretion. As no improvement was gained after three weeks' use of Politzer's method, and no change in the bulging portion of the membrana tympani, I concluded that this curvature was due to granulations lying behind it; so I made an incision, and no change of curvature following, I then entered with the sharp spoon, and cleared out all that I found in the shape of granulating masses, which were pretty coarse in structure. No necrosed particles of bone in the spoon. The air at once passed freely through on using Politzer's method. No inflammatory reaction followed, and a fortnight later the wound in the membrana tympani was healed over, and the hearing became altogether normal after six weeks' treatment.

The patches of carious bone, which belong to the posterior inferior quadrant, offer, on the whole, more favorable chances for healing, and rarer relapses than those of the posterior superior quadrant—a fact which is explained by the less hidden seat of the bony particles to be scraped out, and by the more even, less indented surface of that portion of the posterior inferior quadrant coming into consideration in the field of operation.

The three following cases, which concern the posterior superior quadrant, were more tedious and more complicated on account of growth already existing for a long time within the tympanum; we succeeded, after long treatment, in healing the diseased portions of bone; the disturbances of hearing resulting from the growths described, remained partially constant. These are the cases marked in the heading "relative cures."

CASE XV.—Otitis media chronica, right ear. Spots of carious bone, with granulations in the posterior superior quadrant. Relative cure. Catarrh of the tympanum, *left ear*. Cure after tonsillotomy. Time of observation, 1¾ years.

Von L., student, 18 years old, began treatment April 19th, 1875. The disease of the ear had begun ten years before, during an attack of measles (the case resembles No. X. very much) and otorrhœa and deafness followed, *right*. But within a few days Von L. had noticed tinnitus and deafness in the previously almost intact *left* ear, which condition gave him more inducement to consult me than the suppuration of the *right* ear.

Present state.—*Right*: there was much offensive, cheesy secretion and masses of epidermis in the loosened external auditory meatus; above and behind the processus brevis of the malleus, a perforation half as large as a lentil; behind it, in the posterior inferior quadrant, soft, granulating masses as large as a pea, springing from a crevice. Hearing distance: watch 3″, low voice 1′, loud voice 10′.

Left: membrana tympani drawn in, swollen somewhat from inflammation. Hearing distance; watch 1″, low voice 3′, loud voice 14′. On using the air douche, hissing *right*, entrance with rattling sound *left*. The hearing distance thereupon increased; *right*, low voice 8′; *left*, low voice 25′.

Progress: as the *left* tonsil was much hypertrophied, it was removed with the tonsillotome; under use of Politzer's method, the affection of this ear healed quickly and up to this time it has remained well.

The treatment of the *right* ear offered great difficulties. Cauterization of the granulations caused intense reactive otitis externa, the disagreeable suppuration kept on, but the treatment was often necessarily interrupted, as the patient was here only in the holidays.

In June, 1875, the granulations were removed with the sharp spoon, and the spots of carious bone, found in an indentation of the posterior superior quadrant, were scraped out three times, with pauses of a few days, but probably not boldly enough, for in December, noticeable granulations had again sprung from it. In the mean time, repeated and very painful otitides had set in, probably due to a spontaneous loosening of a small particle of bone. The parts concerned were roughly dug out once more under chloroform, and a pretty large number of necrosed, punctiform particles of bone removed. The subsequent irritation of the chorda, which lasted a fortnight, seemed to me a symptom that the spoon had caught hold of the bony portion in a satisfactory manner. The wound in the bone then healed, the membrana tympani grew clear, and cerumen began to be secreted in the external auditory meatus. The small perforation above the processus brevis of the malleus lasted; hearing distance moderately reduced, watch 3″, low voice 8′. At the last examination, in December, 1876, a year after the last operation, the condition was still as favorable.

CASE XVI.—Large polypus snared off, right. Suppuration stopped. Relapse with carious spots of bone in the posterior superior quadrant. Relative cure. Under observation 2¼ years.

Miss A. S., from Saxony, 18 years old, a strong and healthy-looking brunette, came under my charge in the beginning of November, 1874. She had suffered for eight years, after a disease of childhood, from offensive suppuration and almost complete deafness of the *right* ear. Within eight days, she has complained of fearfully tormenting pains in her head and ears. Inspection shows in the external auditory meatus a tough polypus of such size that it reaches even to the entrance. Hearing distance on this side absolutely null, for voice and watch. The polypus was removed by the snare at two sittings, and an offensive, cheesy, purulent mass, mingled with lamellæ of epidermis, was syringed out; great relief followed. The pedicle of the polpus, which originated in the posterior superior quadrant, was repeatedly cauterized. When the swelling of the parts had ceased, the membrana tympani was seen to be immovable, probably due to adhesions within the tympanum. With the air douche, difficult entrance, no hissing through. Hearing distance increased to, watch 2″, low voice 6′, loud 12′; the purulent secretion ceased, and on leaving, January 6th, 1875, she already had a secretion of cerumen in the auditory meatus

In November, 1876, almost two years later, Miss S. came back to me, because for eight days she had again felt violent pain in the head and *right* ear, and some suppuration had been present for a number of weeks. I found a rather soft, granulated mass, about as large as a pea, at the end of the auditory meatus and removed it with the snare. But again behind it there was a heap of offensive cheesy masses, which seemed to come more from an indentation behind and above (compare case XIV.). The suppuration went on after removal of the growth ; when the swelling of the parts had lessened, I penetrated with the sharp spoon (bent extremely on its plane) around the projection of bone in the posterior superior quadrant, and in this way could scrape out coarsely the rough particles of bone, which, judging from the subsequent irritation of the chorda, evidently extended far into the tympanum. Instillation of carbolic acid. No inflammatory reaction followed, not even after the second, necessary repetition of the operation. The hearing, which had been extremely decreased, arose to : watch 3′, low voice 6′.and in January, 1877, the patient, who had been very down-hearted about her sufferings, was sent homewards relatively cured.

Case XVII.—Spots of carious bone in the posterior superior quadrant. Stoppage of suppuration after two scrapings.

Mrs. H., 36 years old, from Essex, came under my care in July, 1876, after already consulting a long list of specialists for her disease of the *right* ear, which had lasted six years. A spot of carious bone, as large as a small pea, lying in the posterior superior quadrant, hidden behind a projection of bone, was at last, after many examinations, diagnosed as the cause of the suppuration. The handle of the malleus was drawn extremely inwards, and adhesions in the tympanum were the probable cause of the high degree of deafness. The suppuration stopped after two scrapings ; the hearing distance remained slight, loud voice, 8′. Time of observation, eight weeks.

Here follow some cases operated upon in the posterior inferiór quadrant. With the exception of the tuberculous case, they offer, on the whole, a very favorable result.

Case XVIII.—Chalky deposits in the membrana tympani. Spots of carious bone in the posterior inferior quadrant, healed after four weeks' treatment.

F. L., merchant, 18 years old, a strong young man, when a child suffered now and then from otorrhœa and pain in the ears ; later, a pretty constant deafness, *left*. Hearing distance, watch on contact, loud voice 10′. Within a year, the discharge has increased, and is very troublesome, on account of its bad odor. Cheesy, offensive masses of suppuration and epidermis in the external auditory meatus. The membrana tympani is completely calcified; in the posterior inferior quadrant there is a granulation half as large as a pea, with a spot of carious bone underlying it, and stretching away into the tympanum. After scraping out, a reactive inflammation comes on and lasts ten days, then the operation is repeated, the patch of bone heals, the perforation closes. Hearing distance on discharge: watch 3″, low voice 10′. Two months later, at the end of January, 1877, the favorable state of the ear still lasted; hearing could not be further improved, on account of the chalky deposits.

Case XIX.—Scar in the membrana tympani. Spots of carious bone in the posterior inferior quadrant. Cure after six weeks' treatment. Time of observation, 1 year.

Louise V., 12 years old, from Bockenheim, came under my charge February 14th, 1876. This girl, otherwise well, has suffered for several years from occasional pain in the ear, tinnitus, and deafness, *right.* Hearing distance : watch ½″, low voice 0, loud voice 6′. There is a slight purulent secretion in the external auditory meatus; the membrana tympani is irregularly curved, somewhat inflamed, and a yellowish secretion shines at some spots from out the tympanum; a translucent scar is visible in the posterior inferior quadrant. A granulation, half the size of a pea, rests on the annulus tympanicus, upward and outward from the scar.

As repeated cauterizations with the silver wire tipped with argenti nitras were of no avail in preventing a new growth of the granulation, the coarse patch of bone, now discovered, was scraped out with the sharp spoon. An attack of fainting came on and lasted ten minutes; however, the cure by instilling carbolic acid went on so favorably that in ten days the whitish scar in the bone was plainly seen. The subacute inflammation of the middle ear, going on at the same time, healed likewise by the use of Politzer's method. The membrana tympani showed more regular curvature, the light spot came back to view, the hearing increased to nearly normal, and remained constant.

Case XX.—Tough, cock's-comb-like growths, resting on a carious base in the posterior inferior quadrant. Cure after three weeks' treatment. Time of observation, 9 months.

H. L., 21 years old, merchant of Frankfort, has been deaf, *left,* since childhood. Within a few days (April, 1876), there has been pain and also tinnitus, also somewhat increased purulent secretion for a year and a half. Hearing distance small : watch ½″, loud voice 4′. There are offensive collections in the external auditory meatus, made up of cerumen, pus, and epidermis, and resting on the inflamed, reddened, and swollen membrana tympani. On using Politzer's method, after syringing these masses out, the air hisses through. Improved hearing follows: watch 2″, loud voice 18′. The cock's-comb-like growths are now distinctly seen in the posterior inferior quadrant, resting on the annulus tympanicus.

After the subacute stage of the otitis was cured, the growths were cut off, the spots of bone recognized as carious had to be scraped out twice, and then carbolic acid was instilled without any reactive inflammation. Even within three weeks, both the wound of the bone and the small perforation were healed. The hearing distance remained slightly reduced: watch 3″, low voice 10′, loud voice 28′.

Case XXI.—Otitis media purulenta chronica with granulations. Spots of carious bone in the inferior wall of the tympanum. Relative cure. Time of observation, 1½ years.

H. S., 20 years old, a merchant from Ruhrort, came under treatment at the beginning of March, 1875. A sufferer for four years from an offensive discharge and deafness of the *left* ear, he had been treated unsuccessfully up to this time, with innumerable astringents and caustics. Hearing distance: watch 2″, low voice 0, loud voice 10′. A granulated mass, as large as a small pea, springs out from the tympanum in the posterior inferior quadrant of the membrana tympani, which is slightly swollen and relaxed. Air hisses through the perforation, after the mass has been removed with the sharp spoon. The hearing distance at once increased: watch 3″, low voice 10′. Eight days later, the growth had sprung out again; a repeated removal was of no good, the secretion from the tympanum remained muco-purulent; the pedicle of the growth was stroked with argenti nitras in substance, but no noteworthy inflammatory reaction followed. After waiting for several weeks, my opinion now being that the carious spot was to be sought for on the inferior wall of the tympanum, near the annulus tympanicus, I decided to pass the sharp spoon (cutting surface downward) through the perforation, into the tympanum, and then to scrape. There was an abundance of small necrosed particles of bone in the contents of the spoon. Eight days later, the operation of scraping had to be repeated. Instillation of carbolic acid, no inflammatory reaction. The secretion lost its vile odor, became viscid, stringy, and stopped after pulv. alum had been blown in about six times. The old perforation, about as large as a small pea, remained ; the hearing distance increased to watch 6″, low voice 20′.

R. F., engineer, 24 years old, offers a very similar sketch, only there were small patches of carious bone *on both sides*, in the posterior inferior quadrant; the deafness greater (*right:* watch 1″, low voice 4′; *left:* watch 0, low voice 2′) but gradually increased, after eight weeks' treatment. *Right:* watch 5″, low voice 25′; *left:* watch 4″, low voice 16′. Healing of bone, and secretion of cerumen followed.

CASE XXII —Scar in right membrana tympani ; left, defect, with granulating growths in the posterior inferior quadrant ; tinnitus and attacks of vertigo. Relative cure. Time of observation, 9 months.

Louis B., 47 years old, a castellan, came under my charge at the beginning of July, 1876. He had often suffered in childhood from inflammation of the ears and deafness ; *right*, there has been no suppuration for years, but the moderate lessening of hearing has been constant ; *left*, the suppuration has increased excessively within the last four weeks, and is very offensive. Latterly, the patient has complained exceedingly of headaches, violent attacks of dizziness and tinnitus.

State: a moderately extensive scar in the posterior superior quadrant of the *right* membrana tympani, which is drawn inward. The hearing distance is : watch 4″, low voice 12′. *Left:* hearing distance, watch 0, loud voice 6′. A raspberry-like granulating mass, as large as a bean, in the bottom of the auditory meatus, and an offensive secretion. This growth is snared off, and its pedicle is seen to spring from the floor of the cavity in the posterior inferior quadrant. The anterior superior quadrant of the membrana tympani ramains intact. After removal of the masses, the patient was, to be sure, noticeably relieved, but the attacks of vertigo returned, the granulations again grew from the floor of the tympanum outward, and probably caused a pressure on the fenestra rotunda. The spots of bone on the inferior wall of the tympanum, recognized as carious, had to be scraped out three times. Latterly the suppuration has diminished, the granulations have not returned, tinnitus and attacks of giddiness have disappeared. The lining membrane of the tympanum is yellowish-red. Hearing distance : watch on contact, low voice 2′, loud voice 10′.

CASE XXIII.—Defect in membrana tympani. Spots of carious bone at the superior border of the posterior inferior quadrant. Relative cure after eight weeks' treatment. Time of observation, 7 months.

J. S., 26 years old, a butcher of Kalbach, suffered from childhood up from otorrhœa on both sides. *Left*, the suppuration has been dried up for several years, and chalky deposits are visible in the membrana tympani; on the other hand, the discharge has increased much in the last months, *right*, and is very offensive. A raspberry-like growth, as large as a pea, in the bottom of the auditory meatus was snared off. The hearing on both sides was much reduced; on the *left* side, because fresh, subacute inflammation of the middle ear was present; *right* (before removal of the growth): watch 2″, low voice 6′; *left:* watch on contact, low voice 2′. After removing the growth, *right*, a kidney-shaped defect, occupying one-half of the membrana tympani, was seen. As the suppuration did not stop after the operation of removal, the carious spot of bone lying towards the middle of the posterior half of the annulus tympanicus, and from which the growth has started, was scraped out four times, at intervals, each time, of eight days. No inflammatory reaction followed the instillation of carbolic acid, and after eight weeks of treatment, the scar in the bone was plainly seen, the secretion became inconsiderable, and viscid. Five months later, there was a secretion of cerumen.

The operation on patches of carious bone in case of tuberculosis is less successful, as the state of circulation of blood in the periosteum and substance of the bone itself is unfavorable; relapses and profuse suppuration are therefore frequent. Of the two following cases, the second is of predominating interest, because from the deleterious course of an affection of the ear, originating in a seeming state of perfect health, we must conclude that there is present a severe constitutional disease, for which, however, in the first period, in so far as the lungs were concerned, all physical symptoms were wanting.

Case XXIV.—Tuberculosis of lungs, otitis media, with spots of carious bone in the posterior inferior quadrant. Improvement.

J. S., 18 years old, from Trier, now at the neigboring spring on account of an infiltration of the upper portion of the left lung, consulted me in July, 1876. The otitis media had begun acutely, four months before; at first the suppuration was moderate, now it is very profuse and offensive. The *left* membrana tympani is relaxed, reddened, and there is a perforation as large as a lentil, with granulations springing forward from it, in the posterior inferior quadrant. Hearing distance: watch 2″, low voice 4′. After removing the granulations, the small spot of bone recognized as carious was scraped out; under after-treatment with Politzer's method, and solutions of argenti nit., the membrana tympani cleared, the secretion became more viscid and inoffensive; the granulations had not grown again during four weeks' treatment. Hearing distance had increased to, low voice 16′. Farther course unknown.

CASE XXV.—Acute necrosis of portions of the tympanum, both sides. Development of tuberculosis of the lungs. Loss of hearing.

R. E., hospital assistant, 21 years old, came under my charge Nov. 7th, 1876. The young man, hitherto healthy, entered the military service a year ago, as a volunteer for three years. In September, after a very damp night watch, he was attacked with symptoms of an acute otitis media, both sides. In the sixth week after beginning of the attack, I found the periosteum of both auditory meati swollen, very painful, and only a small portion of the loosened and livid-looking membrana tympani visible. On using Politzer's method, the air hissed freely through perforations on both sides. The hearing distance was already slight; *right:* watch 0, loud voice 4′; *left*, watch barely on contact, loud voice 6′. After a fortnight's treatment with the air douche and solutions of argenti nit., the view into the deeper parts became more free, and I distinguished, *right*, a coarse exuberating granulation, which swelled forward from the inferior wall of the tympanum, out through the perforation; the posterior part of the membrana tympani was excessively curved forward (probably also due to granulations). When I cut off the growth, I found already some black particles of bone in the hollow of the spoon, the air hissed more freely through, but the hearing did not increase. Nine days later, the partially discolored granulations had again grown out from the floor of the tympanum, tinnitus and attacks of vertigo (probably due to the pressure of the masses on the fenestra rotunda) had increased. *Left*, granulations likewise showed themselves in the perforation. These were yet once more carefully cut off (both sides) with the sharp spoon, tinnitus and attacks of vertigo diminished. In spite of this the hearing decreased rapidly.

Such an unfavorable course of the local process of disease could only be explained by the accompaniment of a constitutional disease, and, to be sure, just at this time, more distinct symptoms. even on the part of the lungs, became noticeable. By the middle of November, the patient had moderate feverish chills, cough at night, and some expectoration. Still the examination of the lungs did not yet divulge any distinct dulness, but there were some rattling râles at various spots. The patient looked miserable, lost flesh rapidly, and on December 5th, dulness of the apex, *left*, could be now confirmed. About this time, too, I recognized with the sound extensive patches of carious bone in the posterior inferior quadrant *on both sides*, and the chain of small bones seemed already loosened. I therefore desisted from farther operations, and only used Politzer's method, and the instillation of carbolic acid. The hearing was now so slight that we could only in writing make ourselves understood by the poor patient; in this inconsolable state, he was sent home by the military authorities, at his own request, in December. The physician in charge wrote to me at the end of January, in regard to the farther progress of the case, and said that feverishness was continually present, dulness over the lungs had increased, and the patient was totally deaf.

From these cases which I have reported, we gain the fact that the use of the small sharp spoon, and especially in the shape which I first* described, and the operation for which it is to specifically used, has undoubtedly given rapid and favorable results in all the cases in which tuberculosis was not the cause of the disease of the ear. Healing of the formerly carious part of the petrous portion of the temporal bone was gained even in patients affected with constitutional scrofula, whenever the local treatment was sufficiently aided by fit general treatment directed against the dyscrasia. In such cases, the fresh bone showed itself, in all respects, more capable of healing than that full grown; as the former is more easily affected than the latter, so it can also regenerate more quickly after removal of the necrosed portion.

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* The various reviews which have appeared since the publication of the first half of this paper express themselves mostly in assent; while, *e. g.*, the Wiener Medic. Wochenschrift, 1876, No. 28, page 701, says: "The *procedure put forward by Wolf* is to be regarded as an advance in the local treatment of diseases of the ear, not to be underrated;" yet I found in the Archiv für Ohrenheilkunde, which Prof. Schwartze edits, the following remarkable sentence by Dr. Jacoby (Band xi., Heft 3 and 4) "The procedure recommended by Wolf for the cure of caries in the ear (*which, however, has been frequently used by Prof. Schwartze, and is also repeatedly mentioned in his cases* of surgical opening of the mastoid process—*e. g.*, Band xi., page 139, 150) is absolutely judicious, etc."

Leaving out of consideration that Schwartze's publication appeared July 21st, 1876, that is to say, six months *later* than mine, his operation, according to the page cited (139) is as follows: he first makes a large incision in the skin over the mastoid process, opens that with a trepan or gouge, and clears out the mastoid cells with the common surgical sharp spoon. The kind reader will, on making comparison, be unable to find even the most distant resemblance between this proceeding and mine, and so far as I am concerned, I can only explain the oracular expression in question, of Dr. Jacoby, in that he most warmly wishes that Prof. Schwartze *had been the first to discover* the method.

In order not to weary the reader too much with an enumeration of the most varied cases, I have collected chiefly those cases which, leaving the operation out of the question, also offered many interesting points, but I should never hesitate to communicate cases resulting unfavorably, if such had happened, with exception of those becoming deaf through tuberculosis. Up to this time, none of my operations have offered any harm to life or hearing, and I cannot therefore too urgently recommend the right frequent use of the little instrument to my colleagues.

OTOLOGICAL REVIEW.

By CLARENCE J. BLAKE, of Boston.

1. Kuhn. Untersuchungen über das häutige Labyrinth der Knochenfische. *Archiv f. Mik. Anat.*, XIV., 264.

2. Hartmann. Function der Tuba Eustachii. *Archiv f. Anat. und Physiologie.*

3. Kraussold. Primäre Otitis ext. Diphtheritica. *Centralblatt f. Chir.*, No. 38, 1877.

4. Schwabach. Nystagmusartige Augenbewegungen in Folge eines Ohrenleidens. *Zeitschr. f. prakt. Med.*, No. 11, 1878.

5. Ladreit de Lacharriere. De l'influence du tabac sur le développement des maladies de l'oreille et la surdité. *Annales des Mal. de l'oreille et du larynx*, Sept., 1878.

6. Hartmann. Ueber eine neue Methode der Hörprüfung mit Hülfe electrischer Ströme. *Monatschr. f. Ohrenheilk.*, XII., 7.

7. Galton. A Form of Whistle for Testing the Hearing for high Musical Tones. *Physical Society Proceedings*, London.

8. Zaufal. Ueber die allgemeine Verwendbarkeit der kalten Drathschlinge zur Operation der Nasenpolypen, nebst Bemerkungen über das Abhängigkeits-Verhältniss der Erkrankungen des Ohres von denen der Nase. Prag, 1878.

9. Bezold. Fibrinöses Exsudat auf dem Trommelfell und im Gehörorgane. *Virchow's Archiv*, LXX., 3.

10. Kirk-Duncansen. One Hundred Cases of Ear Disease. *Edinburgh Med. Journal*, Mar., 1878.

1. Kuhn in an elaborate paper describes with especial minuteness the histological structure of the terminal nerve portions of the labyrinth in osseous fishes.

In the membranous labyrinth the terminations of the nervus acusticus are eight in number; namely, a macula acustica each in the utricle and saccule, the papillæ basilares of Retzius in the utricle lying near the ramus communicans, a crista acustica in each of the three ampullæ and another crista acustica in the lagena, the analogue of the cochlea in the higher vertebrates. From these nerve endings the macula acustica utriculi and sacculi and the crista acutica lagenæ are each separated by an otolith.

The nervus acusticus divides into a portio vestibularis and cochlearis, the former supplying the macula utriculi, the two papillæ basilares, the crista ampullæ horizontalis and sagittalis, and the latter the macula sacculi, the crista ampullæ frontalis and lagenæ.

The macula acustica utriculi lies at the bottom of the recessus utriculi in the form of a crescentic ridge 3 mm. long, and is composed of three forms of cells.

Undermost are the basement cells, round nucleate cells lying in a simple layer upon the cartilaginous wall of the utricle ; then filiform cells, oval nucleate cells having two diametrically opposite filiform processes, the uppermost of which extends to the free surface of and sometimes beyond the overlying layer of cylinder cells, while others enter the lower pointed end of the cylinder cells. In one case the filiform process was followed into the nucleus of one of the cylinder cells. The third and uppermost layer of the macula acustica is formed of the large round-nucleated cylinder cells, the lower end of which terminates in a filiform process, the flattened upper surface being crowned with a circle of delicate hair-like structures. The nerve-fibres passing to the macula acustica enter the filiform cell-layer as double contour nerve-fibres, then become filiform and form between the basal and cylinder cells a fine network from which spring the processes of the filiform cells. On the macula utriculi rests a globular otolith having a roughened surface and supported by an elastic fibrous basal substance. The otolith is imbedded in a transparent glutinous mass, in connection beneath with a striated membrana tectoria which covers the whole surface of the macula.

On the whole the structure of all the nerve endings and the entrance and distributions of the terminal nerve-fibres resembles that of the macula utriculi ; the only marked variations are found in the covering of the cristæ acusticæ and in the form of the remaining otoliths.

On the surface of each crista acustica lies a structureless cuticular membrane which is penetrated by the hairs of the cylinder cells; over this lies the cupula terminalis, a globular, transparent and, when fresh, semi-solid mass which, covering the entire crista, lies directly upon the cuticula.

The latter is made up of fine fibres placed perpendicularly to the crista, but approaching the centre at the apex of the cupula; the upper surface of the cupula is covered by a structureless membrane.

In the sacculus lies the otolith "Sagitta," of the same structure as the "Lapillus" above described, and imbedded in a similar glutinous mass. The posterior end of the sacculus is continued in the lagena, on the crista lagenæ lies the third otolith "Asteriscus," similar in structure and attachment to the others.

2. Hartmann, following the experiments of Lucae, determines manometrically the degree of pressure necessary to inject air under varying conditions of the Eustachian tube.

By previous observations* he had determined that at +V, the muscles being in a state of rest, air found entrance at a pressure of from 20 to 40 mm. Hg., and that during the act of swallowing 20 mm. and less was sufficient, in other words that the Eustachian tube was correspondingly open. In reviewing these results, he concludes that the pressure given is too low, as it is not always possible to maintain the muscles of the Eustachian tube at rest. In order to test the correctness of this surmise he repeated the experiments in the pneumatic cabinet. The results of the experiments, conducted upon himself and two colleagues having normally patent Eustachian tubes, showed that at +V there was no absolute rest of the tubal muscles. The entrance of air being rendered easier: on increasing the pressure painful sensations, impression and congestion of membrana tympani were produced, and during the act of swallowing these symptoms disappeared. On diminution of the pressure, air passed out of the tympanic cavity with a marked sensation of the passage of air bubbles. Hartmann concludes therefore that much less pressure is required for the exit of air from the tympanic cavity than for its entrance, which he explains by supposing that the Eustachian tubes at rest are like valves opening toward the pharynx. By contraction of the tubal muscles in consequence of phonation during increasing pressure in the cabinet, air did not enter the tympanic cavity. He denies, therefore, that the tubes open during phonation, but concedes that the passage of air is more easily effected.

The case is cited also of one of the gentlemen taking part in the experiments, in whom the Eustachian tubes were open in a state of rest, and in whom the membrana tympani was pressed outward by a pressure of 10 mm. Hg.

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* Virchow's Archiv, lxx.

Movements of the membrana tympani were also visible during forcible respiration, and the entrance of air into the tympanic cavity during phonation was also noted ; these symptoms did not occur in the pneumatic cabinet.

3. Wreden and Moos, following the observations of Bezold on cases which he designated as diphtheritic inflammation of the external auditory canal and membrana tympani, have reported other cases similar in character and pointing to the conclusion that the membrane formed is of primary origin.

Kraussold, however, is not of the same opinion, and maintains that it is not possible to determine the presence of a diphtheritic inflammation of the auditory canal without previous lesion. Secondary diphtheritic inflammation of the middle ear may extend through a perforation of membrana tympani to the outer surface of the membrana tympani and the lining of the external auditory canal, but it is impossible that diphtheritic inflammation should occur primarily in the previously healthy lining of the external auditory canal. In support of this view the following case is cited :

A young woman, 22 years of age, had for some weeks a slight otitis externa with serous discharge ; this was followed by general disturbance, severe pain in the right ear, tinnitus, deafness and feeling of fulness on the right side of the head.

The right auditory canal was nearly filled with a grayish mass, apparently of epidermis which could be removed neither by syringing nor, on account of the tenderness of the parts, by the forceps. The watch was heard only at a distance of $\frac{5}{90}$ cm.

The air douche gave coarse râles and some pain, but did not improve the hearing. On removal of a portion of the mass plugging the meatus, the walls of the canal were found to be red, swollen, tender, and excoriated in patches. Evening temperature was 38.7° C. The mass removed was not examined, as it was supposed to be merely epidermis.

On the following day, the symptoms were the same, and the surface from which the coating had been removed, was covered by fresh exudation. This first led to the inference of a diphtheritic inflammation, which was further supported by the fact of an epidemic of diphtheria in the city. There was, however, no evidence of direct infection. On the fifth day, there was removed, by means of the forceps, a mass resembling the finger of a glove and about 14 mm. long, the extremity of which corresponded to the superior segment of the membrana tympani. The membrane was gray, dense, and elastic, and left an excoriated surface behind it. Three days later, this surface was again covered by fresh exudation which was removed seven days later, small portions being subsequently removed by injection of a solution of salicylic acid. The hearing, which had improved on the removal of the mass, was still further increased by the use of the air douche, and the subsidence of the inflammatory symptoms.

Under the microscope were found delicate reticulated fibres and a few round cells, and on the edges of the mass, pus and epidermis cells. Typical micrococcus masses were not observed.

4. Schwabach reports a case of otitis media purulenta, accompanied by profuse discharge, with swelling and tenderness over the mastoid, severe vertigo upon pressure upon the ear, and in addition the following curious symptom.

Upon pressing above and behind the auricle, the flow of pus was increased from the external auditory canal, without increase of pain, but with marked oscillatory movements of both eyes, the eyes being turned toward the affected side and slightly downward, the size of the pupils remaining unchanged.

These movements ceased so soon as the pressure was removed, but were repeated in a lesser degree on syringing the ear. These movements were accompanied by vertigo as above mentioned. With the improvement in the disease of the ear, these peculiar symptoms gradually diminished. The author bases his explanation of the contraction of the muscles of the globe upon the experiments of Cyon upon rabbits, and assumes an irritation of the semicircular canals, in consequence of the pressure exercised upon the ear. The transmission of the irritation to the cerebral motor centres corresponding to the muscles is unexplained. The frequency of the oscillations was from twenty to one hundred and fifty in the minute; their duration depended upon the pressure, but seldom exceeded half an hour.

5. References to the effects of tobacco in works on aural surgery are rare, and are principally confined to a consideration of its general effect upon the nervous system.

Lacharrière, however, makes a more special mention of the bearing which the habitual use of tobacco may have upon diseases of the ear through the organs of the tympanic cavity, the muscles of the pharynx and palate, and the nerves of this region and of the ear. The consumption of tobacco by smoking the author considers the most deleterious form of use, so far as this special effect is concerned, as the large tract of the buccal, nasal, and pharyngeal mucous membrane, and even the lining of the Eustachian tube is exposed to its influence, the resultant appearances being those familiarly described as "smoker's throat," which is pictured in detail, with the auditory symptoms, those resulting from occlusion of the Eustachian tube, and slight persistent congestion of the tympanic mucous membrane. The muscles of the pharynx also in time become affected and by a diminished fulfilment of their office more readily permit the closure of the Eustachian tube. The second period is characterized by a sensorial depression, the deafness is confirmed, but the subjective noises increase, while the third period is characterized by a progressive paralysis of the auditory nerve.

6. In experiments upon the use of the telephone as a hearing test, Hartmann made use of the following combination.

A tuning fork, 100 vs., to be used as interruptor, was kept in vibration by the current from two Daniell's cells. For the first experiment, the circular compensator of Du Bois-Reymond was interposed, and connection made by twenty metres of wire with a telephone. On diminishing the resistance in the connection with the compensator, the stream passing rhythmically through the telephone was correspondingly diminished. Remarkably short wires (corresponding to weak currents) sufficed to produce the tone in the telephone, and in the compensator used it was not possible to so far diminish the resistance as to make the telephone inaudible. A few millimetres of the wire, one millimetre in diameter, sufficed to notably increase the sound, and a few centimetres of the same wire brought it to its maximum.

For the experiment with the induced current, the tuning fork was placed in the primary coil of a Du Bois-Reymond induction coil, the secondary coil being connected with the telephone by twenty metres of wire. The apparatus employed, medium size, having 5116 windings on the secondary coil, reproduced the tone in the telephone with disagreeable loudness. On withdrawing the secondary coil, the loudness of the tone diminished, and became inaudible in a quiet room only when the secondary coil was withdrawn more than sixty centimetres from the primary coil.

7. As an additional means of testing the hearing for high musical tones, Mr. Galton has devised an exceedingly simple and ingenious

whistle, consisting of a brass tube with the reed opening terminating in a small circular resonating chamber, having a female screw at its lower end. A foot piece with a corresponding male screw fits with a metal casing into and over the bottom of the resonating chamber. On the summit of the male screw is a metal rod which accurately fits the inside of the resonating chamber. The outside of this chamber is marked off in degrees from 0 to 140, and the rim of the casing of the foot-piece is marked off from 0 to 9. The whistle being blown by a small rubber bag, each revolution of the foot-piece upward diminishes the calibre of the resonating chamber and increases the pitch of the whistle, until at 0. 0. the tone has become inaudible to the average normal ear. The instrument is very compact and may be used to supplement the tests with König's rods.

8. In an interesting paper, which is in part a résumé of a portion of his former communications on the subject, Zaufal directs attention to the intimate relation which pharyngeal disease bears to middle-ear affections, both acute and chronic, and to the importance of a knowledge of the normal and pathological anatomical relations of the nose and naso-pharynx in studying the etiology, diagnosis and treatment of middle-ear disease, and notes many important details in regard to methods of examination and of treatment. In regard to the principal subject of the paper, he remarks with justice the insufficiency of the merely rhinoscopic examination and of the removal of nasal polypi by means of the forceps.

The introductory portion of the paper is followed by a description of the gross appearances of nasal polypi and of the hypertrophied portions of the mucous membrane covering the middle turbinated bone with which the former growths may be confounded. For differential diagnosis as to depth and color, he advises the use of the nasal speculum, and for determination of position, size, and consistence, the use of the probe.

In ninety-five per cent of all cases, the growths are found to be mucous polypi. All of these may be removed by means of the simple wire, galvano-caustic being required only for the removal of fibrous growths and the hyperplastic enlargements of the mucous membrane above mentioned.

Following a description of the modified Blake snare is a description of the method of operation, including cautions with regard to the danger of including the swollen mucous membrane in the loop—an accident which often results in profuse and annoying bleeding; to avoid this, the loop should be passed obliquely from without inward over the outside of the polypus, and should be of a size to include the growth only. The seizure of deeply-seated polypi is facilitated by making the patient expire forcibly through the nose at the moment of application of the snare; when mucous membrane has been included in the loop by mistake, the wire may be cut at the outer end of the tube of the snare, and the wire withdrawn.

In cases of extremely narrow nasal passages, or where the swelling of the mucous membrane interferes with the introduction of the instrument, and with proper illumination, he advises the introduction of cotton plugs which are allowed to remain for about ten minutes, their removal being immediately followed by the operation.

In long standing cases, accompanied by abnormal sensitiveness of the parts, the growths should be removed piece-meal, but where the growth is tough and fibrous, it may be torn away with a coarser wire.

For after-treatment the base of the polypus should be energetically cauterized, either with chloride of zinc or nitrate of silver, the latter either pure or, as recommended by Hedinger, fused with nitrate of potash. The cauterization should be repeated every third or fourth day during a period of from two to four weeks, either by the above method or by means of galvano-caustic.

9. Bezold reports three cases of croupous exudation coming under his observation during the past year. In each case there was repeated formation of a fibrinous exudation upon the lining of the external auditory canal and upon the membrana tympani. The false membrane differed from that in the cases reported by Moos, Wreden, Wendt, and Callan in that it was easily removable, that there were no signs of granulations, and no suppuration after its removal; and it is of especial interest that in all the specimens of the pseudo-membrane large quantities of micrococcus were found.

The symptoms in all three of the cases were much as follows:

Without fever or other marked preliminary symptoms, there occurred, either spontaneously or in the course of some other inflammatory affection, fibrinous exudation upon the surface of the membrana tympani and the lining of the external auditory canal. The removal of this membrane was easily accomplished, either by means of the forceps or syringe, but was always accompanied, especially in the earlier stages of the disease, by more or less pain. This exudation recurred usually at intervals of two or three days, and the surface upon which it had spread itself appeared, especially after the first removal, swollen, injected, and slightly excoricated. After the cessation of the exudation process, recovery progressed rapidly without cicatrization or other lasting evidence of the past disease.

This pseudo-membrane was distinguishable from the common layers of epidermis by its yellowish sodden appearance, and by its elasticity. Microscopically, it presented the appearances which characterize the membranes occurring in the larynx in croup; namely, a fine fibrous network, including round cells, nuclei, epidermis, and micrococcus.

In describing the differences between these cases and those of Moos and Wreden, Bezold bases his opinion as to the croupus nature of his cases upon the delicacy and vascularity of the epidermoid covering of the lining of the external auditory canal, which would permit, under sufficient irritation, the occurrence of a form of inflammation usually peculiar to mucous and serous membranes.

Bezold doubts the etiological importance of the presence of micrococcus, and concludes his paper with a contribution from Dr. Schoeninger (assistant in the Munich Pathological Laboratory), who is of the opinion that the micrococcus was present at the time of the occurrence of the exudation and developed as a secondary accidental symptom.

10. Among one hundred cases of aural disease reported by Dr. Kirk-Duncansen, the following are especially interesting.

A patient with rudimentary auricle, the auricle being represented by a longitudinal elevation of the skin, upon which was a process corresponding to the lobule, and in place of the external auditory canal a simple depression. On this side the hearing was absent, the other ear was normal.

Malignant growths occurring in a case of purulent otitis media complicated by mucous polypi, long under treatment. The malignant growths distending the external auditory canal, implicating the auricle, and accompanied by intense pain. These growths were frequently removed, recurred readily, and finally terminated fatally.

A membrane simulating the membrana tympani, and closing the external auditory canal at a point midway between the meatus and membrana tympani in a boy sixteen years of age.

Two cases of hereditary syphilis, in which the ears first showed symptoms of disease at the time of puberty.

A case of otitis media hypertrophica, in which the severe tinnitus was finally relieved by prolonged administration of muriate of ammonia.

Four cases of deaf-mutism, in one case the result of secondary cerebral tumor.

ARCHIVES

OF

OPHTHALMOLOGY

AND

OTOLOGY.

EDITED IN ENGLISH AND GERMAN

BY

PROF. H. KNAPP, M.D.,
OF NEW YORK,

PROF. S. MOOS, M.D.,
OF HEIDELBERG,

AND

PROF. L. MAUTHNER, M.D.,
OF VIENNA,

IN CONJUNCTION WITH

DR. E. GRUENING, OF NEW YORK, AND DR. CL. J. BLAKE,
OF BOSTON.

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OPHTHALMOLOGICAL PART.

CONTRIBUTION TO THE KNOWLEDGE OF THE FINER STRUCTURE OF THE EXTERNAL SEGMENTS OF THE RODS IN THE FROG'S RETINA.

By M. J. DIETL.

(From the Physiological Institute in Innsbruck.)

(Figs. 6–16, Plate I.)

Translated by Dr. B. Bettman, Assistant Surgeon to the New York Ophthalmic and Aural Institute.

The question pertaining to an axial structure in the external segments of the rods is not to be considered as one entirely settled or answered. It has rather of late again assumed form in Schwalbe's excellent treatise.* Ritter† set out in his investigations by the examination of fresh objects, but was only able to demonstrate his deductions concerning the connection between "the rod granule" and the external segment by the application of powerful reagents; hence, he, as well as his successors in this question, Manz‡ and Schiess,§ were accused of having produced, by the method employed, artificial products, for the pre-existence of which we have no guarantee whatever. Hensen's¶ peculiar views are also known. He divides the rod into a cortical and medullary substance, and observes in the latter several (three) fine threads forcing their way from the inner segment. He conceives these threads to be analogous to the ciliæ of other epithelial cells of organs of special sense. The circumstance that, besides other great histologists, above all Max Schultze, who has the greatest experience on this subject, did not acknowledge‖ an axial structure in the outer segment, tends to induce all later workers to maintain the greatest precaution in their interpretations and strictest moderation in their observations. In fact, our field of work here is such as to allow a greater scope to interpretation than elsewhere.

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* Handbuch der ges. Augenheilkunde von Gräfe u. Sämisch I., 1. Thl., page 401 u. f.

† Arch. f. Ophthalmologie, V. II., page 101.

§ Ebenda, III. Reihe, 18, page 129.

‡ Zeitschrift f. rat. Medicin, III. Reihe, 10, page 305.

¶ Virchow's Arch., 39, page 490.

‖ Stricker's Handbuch der Geweblehre.

The history of this question, with all its literary details, has been so fully developed in allied treatises (compare Hensen, l. c., page 484, and Schwalbe, l. c.) that a mere reference to the same is sufficient; the more so since my observations were not obtained by similar methods. It follows from the representations of earlier investigators that the results obtained by the application of reagents could not be relied upon. Only fresh elements could be observed. I would scarcely have obtained better results by this method than my predecessors, had I not utilized several circumstances which have, perhaps, for this purpose occasioned too little attention, but are, according to my views, conducive to good results. I mean, namely, the examination of the questionable retinal elements and their respective parts; while the same are in such a motion, either accidental or intentional, as does not hinder observation. Conditions are often thereby brought under our observation which otherwise would have escaped notice.

If we carefully remove from the fresh eye of a frog a part of the retina, and spread it, with its outer surface looking upwards, in fresh aqueous humor, we will see, especially in specimens that have been kept in a dark locality, the circular globules of the rods tinted with a fiery red, and amongst these others having the beautiful color of green copper salts. These colors fade very soon, as is well known, and we but seldom succeed in recognizing, even for a short time, the red color of the single rods which float about in the aqueous humor near the retina as isolated elements, and represent the proper objects for examination. Nevertheless they will still be considered fresh in this condition, as well as later on when the retina will be altogether bleached, especially as long as they retain their characteristic cylindrical form and as characteristic grooving on the outer surface. We find such rods isolated and indeed with outer and inner segments joined, or wholly separated.

The external segment has at times a granular globule appended, *i. e.*, the already swollen inner segment, in which case the lens-shaped body is no more to be seen,—or the outer segment has only a shining hemisphere hanging from it, which I must interpret as the lens-shaped body of the missing inner segment. This half-globe usually rests with its flat surface against the inner surface of the outer segment; there is, however, no scarcity of cases in which this half-globe assumes also a more spherical form, rendering the connection less broad and intimate. We perceive the connection to be a very intimate one, as soon as the fluid of the preparation is, either intentionally or accidentally, set in motion. The sphere is then seen to swing from side to side, while the cylindrical portion is in a more or less quiescent state. The existence of an intimate connection cannot therefore be doubted, its nature merely remains to be recognized. This question is not without its difficulties, especially as regards the interpretation of the phenomenon. If we closely observe rods whose spheres have these pendulum-like motions, we will find some in which a bright line flits shadow-like in the rod itself from side to side, isochronously with the movement of the sphere, slower or faster according to the intensity of the motion. At the first glance we receive the impression of a luminous thread floating in the outer segment of the rod, intimately connected with the sphere (the lenticular body) (Plate I., Figs. 1–4). Occasionally the globe is detached, but in its stead only a tear-shaped rudiment is found, performing, however, in a similar manner all the above-described movements (Plate I., Fig. 10).

Before analyzing these observations more thoroughly, I should like to express myself with greater precision regarding the structure of the outer segments of the rods. These are undoubtedly separated into a resisting cortical and soft medullary substance; I avoid using the term axis-substance, for it appears to me improper, considering the thinness of the cortex. The growing of the cortex is nothing else than a cuticular formation, as is seen to occur elsewhere in typical forms, on epithelial cells. The cortical substance alone constitutes a hollow cylinder, of test-tube shape; if the inner segment upon which the cylinder rests swells, the open rim may turn out, thereby allowing the demonstration that the grooved outer surface participates in this formation (Plate I., Fig. 8).

The division of the outer segments into small plates is assuredly preformed; to the many other known reasons I would still like to add the observation, that often fresh rods are found from which pieces have been broken off with recurring regularity (Fig. 11); these are in a certain measure segments of one or more plates, and the rods show at the places of fracture rectangular notches. Precisely this circumstance furnishes another admirable proof of the existence of a cortical and medullary substance, a portion of the ring-like cortical substance having been broken off.

The differentiation into a cortical and medullary substance is far better demonstrable in fresh rods than later on, when the division into plates has taken place, and can be best seen by observing the rod mosaic from above. This differentiation, furthermore, is made more prominent by finding at the inner end the whole edge of the cortical cylinder (Plate I., Fig. 8), by its change of form during the swollen condition of the inner segment (Plate I., Fig. 8), and, furthermore, by the peculiar splitting off of the peripheric portions of the plates as above mentioned. Besides these, other reasons will be given below, bearing on this question. I wish here mainly to call your attention to the difference in consistency between the resisting cortical and soft medullary substance; it is the latter substance which allows the excursions of the above mentioned axial fibre.

Doubts as to the entity of the axial fibre are still to be entertained as long as the same is not brought before our eyes in an isolated condition. An important objection,* which I was obliged to make, kept me busy a long time. The luminous streak which passes through the rod is entirely an optical phenomenon, depending upon the grooving and brought

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* A practised histologist will not confound the axial fibre with longitudinal slits, to which Braun calls our attention in the report of the session of the Imper. Acad. at Vienna, XLII., page 15.

about by reflection and its peculiar refractive conditions. This objection would be with difficulty set aside if only rolling rods were always perceived, but it would be easily overcome if the rods, as such, remained quiet, and only the sphere and thread performed the motions—and such examples are in fact found. Outer segments are chosen, which are provided with a ball and visible streak, and besides these possess another characteristic mark by means of which the movements of the rods themselves may be exactly watched. Chance throws many a favorable opportunity in our way. I have seen rods such as these, from the cortical substance of which small peripheric pieces, corresponding to the small plates, were broken off. If the fracture is a lateral one, the slightest movements about the axis are observed by the change of the right angle which represents the fractured part. A half revolution on the axis places it, the fracture, on the other side. Rods may be chosen which are actually bent, and we are thus enabled, in favorable specimens, to demonstrate in both cases that the luminous line and the sphere execute their movements irrespective of the movement of the rod about its axis. The luminous line moves then often obliquely, and at an acute angle to the groove (as in Fig. 1), yea, it may bend around at the inner end almost at a right angle (Fig. 2), and thus demonstrates the connection with the sphere, situated laterally or sometimes hanging over the open edge (Figs. 2, 3). Such pictures prove that the luminous line is in no way connected with the grooving, but is to be considered as an independent structure. In considering these pictures, it appears to me that those conditions also are wanting by means of which Krause's mirror experiment becomes such an important objection to the interpretation of the longitudinal lines, and of the dark points in the optical cross sections.* The whole appearance of the streak described in my observations may be differentiated from that dark line still observed in those outer segments which retain their grooving. This line is evidently to be explained by the existing refractive conditions.

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* Krause, Die Membrana fenestrata der Retina, Leipzig, 1868, page 22, und Arch. für mikr. Anat., XII., 4, 1876; die Nervenendigung in der Retina, page 762.

If the motion of the rod itself is impeded, while a strong current of the fluid forces the sphere against the edge of the open end, it may happen that the edge, by means of the axial fibre, is bulged out beak-like. This appearance ceases as soon as the current stops or takes another direction: a phenomenon demonstrating the resistance of the cortex as well as of the fibre, and throwing a better light upon the difference in consistency of the individual parts.

But there was yet another observation which caused me great doubt and hesitation. We often observe the sphere to be connected with the outer segment by means of a well-marked thread (similar but still longer forms than in Plate I., Fig. 1), but we miss the oscillations, and perceive that the connection takes place only at the edge of the inner end of the cortical substance. I have therefore considered the possibility, that this connection denotes either nothing else but the torn sheath, which envelops the outer and inner segments, or that the axial fibre has become adherent peripherally throughout its whole length to the cortical substance, and thus has escaped observation. The first possibility cannot be dismissed, since a delicate envelope, transparent as glass, and which passes from the outer to the inner segment, certainly exists. We are sometimes enabled, especially when the preparation is moved, to observe this envelope directly and distinctly by means of its folds (compare, also, Merkel, Arch. f. Anat. and Physiol. by Reichart and Du Bois, 1870, page 648). Now, if this envelope tears, it may be changed into a fine thread which fastens the globule anywhere to the open cortical edge of the external segment. Does not this become a source of delusion? These pictures have confused me again and again; still when I thought of all that I formerly observed, and when I again saw other rods in which the existence of an axial fibre was beyond all doubt, I was able to draw with more ease the conclusion that two kinds of connections may exist between sphere and external segment. In one case, the connecting membrane is altogether lost, the connection being made by the axial fibre; in the other case, the membrane is partly torn, and we perceive the connection only by means of the remnants.

Occasionally we also come across rods which are broken in the middle, but the two fragments are intimately connected by a resisting thread, and, indeed, at their axis (Plate I., Fig. 5). In this case it becomes difficult to determine whether this is the above-described thread, or, more likely, the tense and extended transparent membrane, or both structures. A peculiar elasticity must be presupposed for the membrane. The axial fibre, on the contrary, might be drawn out of its surroundings, *i. e.*, the soft medullary substance.

The picture sketched in Fig. 11 may aid in rendering the interpretation more intelligible. The fragments of these rods broken in the middle are displaced directly in the plane of fracture. The connection by means of an axial fibre of a certain resistance might easily explain this; whilst, on the other hand, we would be unable to account for the non-separation of the fragments in another direction (parallel to the axis), considering that the connection is only that of a frail enveloping membrane. Thus numerous examples argue in favor of the existence of an independent axial structure in the external segments of the rods, without its being feasible in the single instances to represent the same as positive and altogether unequivocal. With such a subject for observation, and considering that we are near the limits of microscopical observation, this will not occasion too much wonder. If we consider, on the other hand, that a host of other authors have, by different methods, arrived at the same conclusion, we have to admit at least that the question of an axial structure in the outer segment does not lack reality. I refer to the occasional remark of H. Miller, according to which he observed a differentiation of a granular thread in the axis of the rod preserved in an ocular fluid. I have seen these forms and represented several in Plate I., Fig. 9. If we consider, furthermore, that the pictures obtained by Ritter and his successors correspond to a condition based upon facts which must be due to corresponding identical causes, my observations with fresh specimens may serve as a corroboration. The experience of earlier authors who interpret their observations in a similar manner as I do, affords me also a certain indorsement. It will be observed, however, that in the above statements I do not declare my own interpretation as the only admissible one.

In the foregoing lines an enveloping membrane of the outer segments has often been referred to, and its existence considered as established. But Merkel,* in opposition to Landolt†, has denied its presence in amphibious animals. Schwalbe‡ is of the same opinion as Merkel. Although I myself doubt that Landolt observed the true transparent membrane, I must, nevertheless, express myself with decision in favor of its existence in the outer segments of the frog's retina. Of course, we do not see it under ordinary circumstances, no more than Schwann's sheath is observed in medullated nerve-fibres or the sarcolemma in striped muscle-fibres. The transparent membrane may be classed with the most delicate subjects of microscopical anatomy. But it is unequivocally seen under circumstances similar to those which bring Schwann's sheath and sarcolemma to our view. In recently-broken rods, with the vitreous membrane preserved, the fragments are only connected by means of this membrane, which can be well seen when the fragments are forced apart, and also when they arrange themselves at an angle (Fig. 4, *a*, *b*).

But when fluid accumulates between the membrane and rod-substance by whatsoever cause, the former is found raised from the latter, and it is very instructive to observe how, for instance, a passing rod turns aside from the observed rod, and rebounds from the elevation formed by the detached membrane.

These observations are sufficient to prove the existence of a very delicate, transparent connective-tissue sheath, which closely envelops the outer segments of the rod in the frog's retina.

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* L. c., page 645.

† Arch. f. micr. Anat., VII., page 92 u. f.

‡ L. c., page 411.

CAMPIMETRY IN DR. HIRSCHBERG'S EYE CLINIC.

By DR. PUFAHL, Assistant Surgeon.

(Plate II.)

Translated by DR. B. BETTMAN, Assistant Surgeon to the New York Ophthalmic and Aural Institute.

1. *Measurement of the Field of Vision.*

WE are not accustomed, in the ophthalmoscopic era, to content ourselves with the expressions "good, moderate, bad" vision, but, by means of graduated test types, apply a numerical expression to central vision.

Considering that Albrecht von Graefe had called our attention, in the year 1855 (Archiv f. Ophthal., II., 2, 258), to the significance of the measurement of the visual field, especially for the prognosis of amblyopia, we ought no longer to content ourselves with the expressions "good, bad" field of vision, but ought rather to adopt a graphical representation of the visual field of every amblyopic eye, in order to enable us to make an exact comparison with future conditions of the same eye, or the relation it bears to other eyes. Besides, it is easy to comprehend that the examination of the entire visual field is really more important than that of central vision, since the former embraces a test of the entire retinal expansion, while the latter refers only to a smaller part, which, although physiologically the most important, must not by any means be always the locality of pathological processes.

The endeavor to make a differential diagnosis from the extent of the visual field alone is just as unfeasible as to determine a thoracic disease merely by means of auscultation; but the examination of the visual field is indispensable in order to characterize the various forms of amblyopia, and especially important in its relation to the acuity of central vision.

The extent of the normal visual field has been determined by various authors:

Förster found the extent, reckoning from the optic papilla, as follows: upwards, 45°; downwards, 65°; outwards, 70°; inwards, 60°.

Landolt's measurements were: upwards, 55°; downwards, 65°; outwards, 85°; inwards, 50°.

According to Usckakoff and Reich, the visual field is somewhat smaller in myopes and larger in hypermetropes than in emmetropes. The blind spot, corresponding to the optic-nerve entrance, extends in the retinal horizon from about 12–18°. Fig. 1 represents a sketch of my visual fields as tested by me with the perimeter; the drawn line indicates the boundary for white light (in contradistinction to darkness); the first of the dotted lines indicates the boundary for blue, within the limits of which a blue-colored square, eccentrically seen, is perceived in its specific color; the second denotes the boundary for red; the third for green. The measurement was determined by squares of 5 mm. in length, at a distance of one foot.

It is not my intention to give, in the following pages, a summary of all the abnormal visual fields measured during the last year. I desire only to dwell upon some essential points, especially since the books of Schön* and Pauli † furnish interesting information concerning the subject in question. The normal expansion of the visual field may be interrupted, in the first place, by a circumscribed spot of either total blindness or diminished sensibility to light (scotoma); secondly, the normal field of vision may be narrowed from the periphery (peripheric limitation of the visual field). Both defects may exist combined.

At first I may mention that a careful examination upon the blackboard elicits the smallest scotomata, circumscribed defects of less extension than Mariotte's spot, scotomata the diagnosis of which would otherwise be impossible.

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* Die Lehre vom Gesichtsfelde. Von Dr. W. Schön, Berlin, 1874. Bei A. Hirschbold.

† B iträge zur Lehre vom Gesichtsfelde. Vom Dr. Richard Pauli, München, 1875.

Case I.—Jan. 17th, '76.—A young lady, æt. 18, complains of a haziness before the left eye, existing for three weeks. Both eyes Sn. XX., at 15′, Jäg. 2 at 18″. Right E. Ophth. normal.—Left: in the inverted image,* a circumscribed white spot (choroidal atrophy), excavated in the middle, is perceived at the temporal side and close to the papilla. Accordingly a small scotoma was found at the temporal side of Mariotte's spot, but of lesser extent than this, and between the two a portion with excellent perception. Under antiphlogistic treatment the indistinctness of vision disappeared whilst the defect diminished almost to imperceptibleness (Plate II., Fig. 2).

The diseased spot was of course visible with the ophthalmoscope in the foregoing as well as in many other cases, but the physiological significance of so small a spot in the tissues of the eye, and its importance to the person concerned, can only be determined by a measurement of the visual field. Such circumscribed spots may, without producing any visible change in the ophthalmoscopic picture, permit a return of the perception of light at the affected place; occasion, on the other hand, a permanent scotoma; or, by perforating through the anterior layer of the retina, destroy the function of a bundle of nerve-fibres, and thus produce a sector-like visual defect continued from the spot originally diseased.

Case II.—March 7th, '76.—A young man, æt. 19, complains of a small spot before the left eye. With the aid of his spectacles $-\frac{1}{12}$ he reads Sn. XX. at 15′, and Jäg. 2 at 5″. The limits of the visual field are normal; at the temporal side of the optic nerve a scotoma appears (s. Fig. 3). With the ophthalmoscope we discern (in the inverted image) externally two small grayish-blue patches over which the retinal vessels run. We advised local bleeding, mercury pills, and rest in the dark. After the lapse of a few weeks the spot in the visual field had disappeared, but the ophthalmoscopic picture remained unchanged (s. Plate II., Fig. 3).

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* I shall use the inverted image in this paper (although we also examine every case in the upright), on account of the conformity with the delineated field of vision, the upper boundary of which naturally corresponds to the lower boundary of the retina, etc.

Case III.—July 2d, '77.—A lady, æt. 48, the wife of a physician, came to consult me about a spot which remained, after an eye affection (retinitis hæmorrhagica) contracted in the foregoing year. The spot had lately grown larger. Each eye reads with $+\frac{1}{40}$ Sn. XX. at 15′ and Sn. $1\frac{1}{2}$ 10″. Ophthalmoscopic image of the right eye is normal. In the left eye we observe a light veiling of the margin of the papilla and externally and inferiorly to the same a grayish-white retinal spot, not much larger than the papilla. The scotoma corresponding to the spot is not the only defect we find in the visual field, as a sector-like defect, corresponding to the bundles of nerve-fibres, affected by the focus of disease, is also brought to view. Every congenital defect, every acquired interruption of the retina, manifests itself by a scotoma, but the cases of most interest are those in which the scotoma, so to speak, represents a galvano-plastic impression of the retinal defect.

Case IV.*—Sept. 13th, 1877.—Examined a young man with congenital amblyopia of the left eye; Sn. CC. at 15′. The ophthalmoscope shows in the inverted image a congenital defect of the retina (coloboma, dictyoschisma), situated about three papilla diameters above the point of fixation; this deficiency is represented by a bright excavated and elliptically limited spot bordered with black pigment. A corresponding elliptical figure, whose largest diameter approaches 15° of an angle, is found above the point of fixation.

I cannot allow this opportunity to pass by without mentioning that the large typical colobomata of the retina and choroid, corresponding to the depressed places, show a complete defect of the visual field.† Although the question pertaining to the existence of remnants or an analogon of the retina in such affections is still a disputed one from a histological stand-point, it has been decided from a physiological point of view that percipient retinal tissue does not exist.

Case V.—March 11th, '77.—Man, æt. 27. Left S. = 1, M. $\frac{1}{16}$; limits of visual field normal; Right, Sn. $1\frac{1}{2}$ at $2\frac{1}{2}$″. Counts fingers at 4′; with —3 Sn. Left 15′, but cannot see small letters close to the eye; limits of the visual field (Fig. 4).

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* Comp. Dr. Hirschberg, Arch. f. Ophth., 1875.

† Comp. Dr. Hirschberg, l. c., page 186.

The objective examination of the right eye shows a coloboma of the lower part of the iris, a coloboma lentis, and a coloboma of the retina and choroid. In the inverted image close to and above the papilla a very large bluish-white depression, elliptical in form, is seen, over which few small arterial branches of the retina pass, but from which large unusual blood-vessels emerge. This well-defined elliptical depression is surrounded by a narrow bright border which shows anteriorly the well-known beak-like pigment figure.

Case VI.—The following case is also very likely a congenital one. Jan. 13th, 1877, a young man, æt. 17, came to me on account of a slight divergence of the left eye. The right eye is perfectly normal, counts fingers with the left at 14′. Recognizes with difficulty letters of Sn. VIII., and reads slowly with +6, Sn. 3½ at 4″. A bluish bright cord extends from the optic nerve (in the inverted image) inwards and somewhat upwards, expands funnel-like above the centre of the retina, and terminates in a dark, black pigment spot which is bordered by a bright-red discoloration. Campimetry develops a paracentical scotoma, which extends upwards and outwards from the enlarged optic disc, and corresponds exactly to the described abnormality (s. Fig. 5).

Dr. Hirschberg described and demonstrated by means of illustrations a scotoma corresponding to a foreign body which had penetrated into the retina (Berliner Klin. Wochenschrift, 1875, No. 22).

Campimetry becomes still more important in the interpretation of conditions in which a central scotoma develops, whilst the ophthalmoscope indicates either no change or so slight an alteration that we are unable to infer the existence of a scotoma. Central scotoma occurs symmetrically in both eyes as the expression of an affection of the nerves; after some time, the temporal half of the papilla optica becomes pale. The location of the focus of disease in the optic-nerve fibres cannot be determined as yet with any degree of certainty. In a department so obscure and therapeutically of so little satisfaction, the prognosis is of the greatest importance.

And here again Graefe's investigations opened the way to future observations. If a sharp, circumscribed scotoma exists, whilst, after frequent examinations, the periphery of the visual field remains normal, the patient will not become blind, no matter how pale the optic nerve may appear. But if, on the other hand, contraction of the peripheric visual field occur, amaurosis is to be feared, though the change of the optic nerve be but trifling.

Case VII.—August 10th, 1874, a young man, æt. 27, came to the clinic complaining of inability to read. The ophthalmoscope revealed partial atrophy of both optic discs. Recognizes fingers with each eye at a distance of 8′, deciphers with difficulty Jæger 15 held close to the eyes. The field of vision displays normal outer boundaries and central scotoma. The treatment consisted of diaphoretics and purgatives, iodide of potassium was given, and Heurteloup's leech applied. A moderate but still decisive improvement was obtained. Nov. 22d, 1874.—Read with either eye Sn. CC. 15′; Right, Sn. VII½ with difficulty, Left, Sn. X. 6″. After the lapse of one year and a half, the conditions remained unaltered. A special cause of the affection could not be determined.

Case VIII.—A man, æt. 51, has had impairment of vision for a long time, without any accountable cause and without being benefited either by diaphoretics or other internal remedies. Left eye recognizes fingers at 8′, right eye at 5′, with +6 scarcely discerns letters of Sn. XX. Ophthalmoscopic examination shows atrophy of both optic papillæ, and campimetry a normal extent of the visual field with marked scotoma centrale (s. Fig. 7). Notwithstanding the bad function and unfavorable ophthalmoscopic appearance, a good prognosis could be given and further observation verified this prognosis.

The above-mentioned prognostic sentence of Von Graefe has also been doubted, although I think it very important to lay particular stress upon the signification and validity of Von Graefe's assertions. The repeated, thorough examinations of many hundred amblyopic patients in Dr. Hirschberg's clinic have confirmed the correctness of Von Graefe's statements. There are, of course, cases of impaired vision with central scotoma, which are progressive; but in these cases a careful examination always indicates a certain anomaly of the eccentric sight, especially of the eccentric perception of colors, upon which Schön justly laid so much stress.

Case IX.—June 20th, 1875, a strongly built policeman, æt. 53, came to the clinic complaining of a disturbance of vision of six weeks' duration. Reads with either eye Sn. CC. at 15′, with + 10 Sn. 3½ at 8″. A limitation of the periphery of the visual field, either for white or colored objects, was not found. An indistinct not well defined scotoma centrale existed (Fig. 8). The papilla optica had a grayish-red appearance. The cause of complaint not determined. The patient used alcohol and tobacco, but not enough to cause such a disturbance of vision. The amblyopia increased slowly but steadily, notwithstanding total abstinence; vague nervous symptoms associated themselves with this increased impairment of sight. After a lapse of three months, right eye, + 10, reads Sn. V. ; left, only several words of Sn. V.; the papillæ assume a bluish-white color, especially the temporal halves; blood-vessels are narrow. June 18th, 1876.—Right eye recognized fingers at 10′ with + 10 Sn. XI. ; left eye, fingers at 5′ with + 10 Sn. XX., held close to the eye. Scotoma centrale in both eyes, larger in the left than in the right. The outer boundaries for white might appear normal, but are in fact, in comparison with former conditions, restricted, especially on the nasal side. Here the restriction amounts to 12° in the right eye, and 5° in the left. A matter of great importance, however, is the loss of perception for green, while that for red and blue is concentrically diminished. The papilla optica becomes paler, vision diminishes more and more. The impairment of vision, without any considerable limitation of the periphery of the visual field, is so great, that the patient is scarcely able to decipher letters of Sn. XX. with the aid of + 6 ; central scotoma is somewhat extended ; patient complains of headache, excessive debility, vomiting—and succumbs to his complaint, May, 1876.

Amblyopia, occasioned especially by excessive use of tobacco and alcohol, furnished the most interesting examples of central scotoma. In Germany, equal attention is directed to the afore-mentioned causes (as shown by the visual fields pertaining to the following cases). In England, on the contrary, a greater and, perhaps, too great an importance is attributed to the abuse of tobacco ; while a lesser significance is ascribed to the inordinate use of alcohol. The disturbance of vision in amblyopia ex abusu generally consists of central amblyopia with free visual field. In the greater number of cases, central scotoma is present, without any corresponding changes in the centre of the retina.

Case X.—A man, æt. 42, who habitually drinks $\frac{1}{8}$ quart of brandy per day, and who has complained of impaired vision for several months (Right, Sn. XL. at 15′; Left, Sn. CC. at 15′) shows in the worse eye an extensive central scotoma, the centre of which is less dark than the periphery. The temporal half of papilla is white. Vision has improved considerably after an abstinence of six weeks. Right, Sn. XXX.; Left, Sn. XL., 12′.

Truly typical of amblyopia potatorum are such scotomata as are situated on the temporal side of the point of fixation in each eye (Förster).

Case XI.—A man, æt. 38, who has indulged quite heavily in spirituous liquors, and who has seen worse during the last nine months (both eyes Sn. CC. at 15′, Sn. IV. at 6″), shows the sharp, well-defined scotomata (Fig. 11), which inclose Mariotte's spot. We must naturally suppose that the scotomata reach as far as the retinal centre, although the patient locates the indistinctness on the temporal side.

The very same form occurs in tobacco amblyopia.

Case XII.—A man, æt. 70, well situated in life, smokes all the year around fifteen Havana cigars per day. He recognizes with difficulty fingers at 10–12′, reads, Right, Schweigger, 2.25; Left, 4-0 at a distance of 10 cm., consequently Right, S. $=\frac{1}{20}$, Left $=\frac{1}{40}$. The boundaries of the visual field are perfectly normal. On the other hand, a well-marked central scotoma is developed (Right as far as 5°, Left 10°) within which sensibility to colors is entirely extinct, but remains normal throughout the remainder of the retina. This condition remained stationary, the patient being unable to refrain from smoking (Fig. 12).

Case XIII.—A man, æt. 36, confesses to the moderate use of tobacco and whose vision has decreased during the last six weeks (Right, Sn. CC.; Left, Sn. C. at 15′), presents pale papillæ (especially the temporal halves). The boundaries of the visual field are normal. A central scotoma for red and blue exists in both eyes; green appears as chocolate throughout the visual field. Vision, when tested with Stilling's colored test types, is no different than when the ordinary black letters on white background are employed; green with the colored types is confounded with red. After an abstinence of four weeks he recognizes, Right, Sn. XXX.; Left, Sn. XL. at 15′ (Fig. 13). It is not always possible to map out a central scotoma in such cases.

CASE XIV.—A railroad official, æt. 52, complains of impaired vision existing for a year, has smoked for many years, both day and night, his pipe of the strongest tobacco. He presents a yellow, cachectic appearance, eats little, and complains of debility. Ophthalmoscope elicits a pale appearance of the temporal half of the disc. Right eye recognizes fingers at 2′, with +6 Jaeger 20; left eye, fingers at 3½′, with +6 Jaeger 18. Sensibility for green is destroyed; for red and blue still preserved. The boundaries of the visual field, notwithstanding the great amblyopia, are perfectly normal; they extend outwards as far as 85°. A central scotoma cannot be sharply defined.

One form of amblyopia, namely, that of *lead poisoning*, leads rapidly to atrophy. In lead poisoning a high degree of contraction of the periphery of the visual field, and no considerable impairment of the power to distinguish colors, exists in connection with a negative ophthalmoscopic result and tolerable central vision.

CASE XV.—A young man, æt. 29, came to me July 5th, 1876, complaining of impairment of vision of one-half year's duration, and also of lead colic. R. eye recognizes Sn. LXX. at 15′, Left, Sn. C. at 15′; reads Sn. V. 5″ with either eye. Ophthalmoscopic appearance is almost normal, with the exception of a hardly perceptible hyperæmia of the retina. Red is regarded as green, and green as yellow in both eyes. Blue is recognized as such, but only in a very narrow compass. Both eyes possess high degree of concentric limitation of the visual field (Fig. 14).

In amblyopia caused by glaring light (retinitis nyctalopica, according to Arlt) we find a so-called *nervous* central scotoma, *i. e.*, a scotoma proceeding directly from the optic nerve and not due to any circumscribed change at the macula.

CASE XVI.—An educated chemist, æt. 43, who has lately worked a great deal with electric light, complains of disturbance of sight in the left eye; has worn concave one-eighth ever since his 16th year. March 9th, 1877.—R. eye reads slowly a few words of Sn. 1½ at 5″; Left, Sn.

II. at 5″; with −8 deciphers with difficulty R., Sn. XX.; L., Sn. CC. at 15″.

March 7th, 1877.—Left, Sn. V.½ at 5″. Ophthalmoscope shows, in connection with the staphyloma posticum, well-marked hyperæmia of the retina and papilla optica. The outer boundaries of the visual field are perfectly normal; an exquisite central scotoma is observed. Below the point of fixation (20°), a complete defect; above the point of fixation (10°), indistinctness. Ordered Heurteloup's leech, corrosive sublimate pills, and enjoined rest of the eyes. The ophthalmoscopic and functional disturbances augmented shortly afterwards.

March 13th.—The left papilla exhibits a strong capillary injection and indistinct edges. The scotoma has extended so much that it almost embraces the normal visual field for green. Blue and red are distinguished as such beyond the limits of the scotoma. The scotoma consists of three zones: a central portion of indistinct vision; to this is annexed a ring-shaped, absolute defect of sight; then follows a semicircular zone with imperfect sights (s. Fig. 15 *a*). The improvement was marked by an increase, both as to extent and acuity of vision, in the circular plane around the point of fixation.

March 21st.—Left eye reads Sn. 1½ at 5″. Green and red (but not yellow and blue) are distinguished in the central circular plane of indistinct vision, whose radius amounts to from 5°–10°.

March 29th.—The central circular plane has regained normal function and an expansion of 10°–20°. To this is annexed a ring scotoma (s. Fig. 15 *b*) of imperfect vision, within the limits of which a small piece of white paper is regarded as blue, and which possesses, besides Mariotte's, another spot devoid of vision. But the latter defect remained only a few days.

In conclusion, I shall not neglect to mention that we have observed, though seldom, well-marked characteristic forms of scotoma centrale fugax.

Case XVII.—Nov. 19th, 1875.—A woman, æt. 45, complains of impairment of vision of the right eye; left normal; R. eye recognizes Sn. LXX. at 15′, with +6 Sn. V. at 6″, presents normal boundaries of visual field and a central scotoma.

Nov. 23d.—The scotoma has disappeared; with +6 Sn. II. The cure was soon complete and permanent (Fig. 16).

(*To be continued.*)

THE REDUCED EYE.

By Prof. HASNER, of Prague.

Translated by Dr. Cornelius Williams.

It is a fundamental law underlying all physiological functions, that they never depend upon a single factor, but are accomplished by the co-operation of several.

Thus it may happen that deviations in function of one or more factors are corrected by a compensating deviation of others, and the function of the part as a whole remains undisturbed. In this manner a greater scope is given for the anatomical and physical basis of the functions, as is also pre-eminently observable in the eye.

The optical function of the eye rests, as is known, upon three physical conditions: The refractive power of the diaphanous media, their curvature, and thickness; and as the eye is represented by a combined system of lenses, it follows that a particularly broad scope must be conceded the values of the different factors, in order that the normal functions of the so-called emmetropic eye may be accomplished.

The introduction of the schematic eye, or rather the mean normal eye, assumes the determination of the mean values of all the elements of these three groups of factors, the exactitude of which assumption cannot be conceded until the extreme values of these factors are known. Yet it must be admitted that a condition of normal refraction of the eye may exist between these extreme values, even though all the factors deviate from the mean of their value, as the deviation of the one may be compensated for by that of another. The schematic eye, as it was first computed by *Listing*, and later by *Helmholtz* and others, is, therefore, only of value in so far as it offers only one example of the many possibilities in which the combined action of known factors may constitute the optical function of the eye, and present a normal result. But this result, *i. e.*, the fitting of the eye for parallel rays, may be brought about in many other ways. It is well known that not alone in the eyes of vertebrate animals, but also in the human eye the greatest differences exist as to index, curvature, and thickness of the optical media.

Hence, since the measurements of *Chossart*, *Brewster*, and *W. Krause*, many modifications of the optical constants of the human eye have been submitted, and even yet the question cannot be considered as definitely settled. The greatest discrepancies exist as to the focal length of the crystalline body (Total-linse), in the computation of which the greatly varying factors of the index, thickness, and curvature of the cortical, median, and nuclear layers are to be considered. *Listing* therefore computed the focal length of the lens at 43.796; *Helmholtz* at 30.671; and *Reuss* at 63.90. The radius of curvature of the cornea in emmetropic eyes varies between 7 and 8 mm., and the average may be considered as 7.5, if, which is not yet determined, these limits are never exceeded. Inasmuch as the radius of the cornea may be directly measured, it is easier to find the value of both the extremes and the mean.

The computation of the optical axis is, however, more difficult.

Krause's calculation placed it at 22.715; *Listing's* at 22.647; *Helmholtz's*, 22.834; and *Happe's* at 22.8254. But, according to *Mauthner's* computation in the aphakial eye, it even exceeds 23, and reaches 24.1. If the extreme values are 22 and 24, then the mean must be considered as 23. Numerous direct measurements of the optical axis are very desirable, for the values given above are in all probability only results of computation, and hence more ideal than real.

The schematic eye is an ideal one, it is aphakial and reduced, and contains two separating planes (Trennungsflächen) very near each other, between which lies a space termed idle by *Happe*, or rather, one separating plane moving in the so-called idle space. The real eye, however, has actually no such moving plane. Neither does it possess that considerable reduction of the total index of refraction, nor the reduced radius of curvature. On the contrary, refraction takes place on each of the numerous separating planes, which, by assuming a total index of refraction for the body of the lens, may be reduced to three in number, to wit: the cornea, the anterior and posterior planes of the lens.

So far as is known to me, no one has latterly computed the path of the rays of light in the eye, but the calculation always consists in deductions from each of the cardinal points of the metamorphosed system.

It, therefore, does not seem superfluous to compute the actual refractive conditions of the light by choosing the optical constants lately accepted by *Helmholtz*—in order to prove that we also arrive by these simple means at the same result as regards the position of the focal points. The computation is accomplished by the aid of the values of conjugate foci developed from the fundamental equation of the refraction of light on spherical surfaces.

1st. *Refraction by the cornea.*—Parallel rays falling upon the front surface of the cornea are united in its posterior principal focal point, F_2. Now F_2 is $=\frac{n_2 r}{n_2-n_1}$. *Helmholtz* puts the value 7.829 mm. for the radius of the cornea r, its refractive power $n_2=1.3365$; hence $F_2=\frac{7.829\times 1.3365}{0.3365}=31.09497\ldots$ This value we shall express by 31.095.

Refraction by the anterior surface of the lens.—In the first place, the principal focal distance of this surface, which has a radius of 10 mm., is to be determined. The refractive power of the aqueous humor $n_1=1.3365$, that of the lens $n_2=1.4371$. Hence the anterior principal focal distance is

$$F_1=\frac{n_1 r}{n_2-n_1}=\frac{1.3365\times 10}{1.4371-1.3365}=132.85288,\text{ and the posterior is}$$

$$F_2=\frac{1.4371\times 10}{0.1006}=142.85288.$$

The anterior surface of the lens lies 3.6 behind the cornea. Rays leaving the latter and converging to 31.095 must of necessity unite behind the anterior capsule of the lens at 31.095

$-3.6=27.495$. This is the negative object distance of the lens, therefore $f_1=-27.495$. The expression for the distance f_2, at which images are formed, is $f_2=\frac{f_1F_2}{f_1-F_2}$, therefore

$$f_2=\frac{27.495\times 142.852}{27.495+132.852}=24.495118.$$

Refraction by the posterior surface of the lens.—Rays which would unite at 24.49 behind the anterior capsule, now fall upon the posterior capsule, which is separated from the anterior by an interval of 3.6. Hence $24.49-3.6=20.895118$, the distance at which the rays come to a focus behind the lens. This value is, however, a negative one.

The radius of the posterior surface of the lens $=6$

$$F_1=\frac{1.3365\times 6}{1.4371-1.3365}=79.71172$$

$$F_2=F_1+r=85.71172.$$

To ascertain where the rays are united behind the lens, we avail ourselves of the formula $f_1=\frac{f_2F_1}{f_2-F_2}$, as $f_2=-20.895$, we ascertain the value of f_1

$$f_1=\frac{20.895..\times 79.7..}{20.8..+85.7..}=15.62361.$$

If we add to this value 7.2, *i. e.*, the position of the posterior capsule, we find the posterior principal focal point, or the length of the optical axis $=22.82361$. The region of the posterior focal point, according to *Reich*, is 22.834, and as corrected by *Happe*, 22.8254. The difference between the value obtained by us and that estimated by *Happe* amounts to only 0.00179, and the agreement is almost complete.

Course of the rays of light in reverse order.—If we wish to determine the region of the anterior principal focal point, we must take into account the refraction undergone by the rays which were parallel in the vitreous humor, as they pass through the lens and cornea. Inasmuch as the posterior focal distance of the posterior capsule is $=85.71172$, it follows that rays after refraction by this capsule are given a convergence which would unite at a point 85.7... in front of it. Falling upon the anterior capsule we have $f_2 = 85.7.. - 3.6 = -82.11172$. Further, as above, $F_1 = 132.8...$ and $F_2 = 142.8...$; hence

$$f_1 = \frac{f_2 F_1}{f_2 - F_2} = \frac{82.11... \times 132.85...}{82.1.. + 142.85} = 48.491089.$$

At the cornea the rays converge to $48.4... - 3.6 = 44.891089$; this value being negative. Since $F_1 = 23.266$ and $F_2 = 31.095$, so

$$\frac{f_1 = f_2 F_1}{f_2 - F_2} = \frac{44.89... \times 23.2..}{44.89.. + 31.095} = 13.7451.$$

Rays which are parallel in the vitreous are united 13.7451 before the cornea. This is the anterior principal focal distance. *Helmholtz* and *Reich* computed it at 13.7525, *Happe* at 13.7451, which last value corresponds fully with that obtained by us. By the method adopted by us, we are enabled accurately to determine the position of the focal points. But the focal distances, it is true, are not yet determined. We shall next compute these after the *Gauss-Listing* formulæ. But as the free space which is allowed here is very small, and the errors in the determination of the refraction as well as in the calculation of the radii are to be taken into account, *Listing* had already proposed to compute the focal distances upon the basis of one principal point and one nodal point, which, of course, presents the case in a different light. The simple principal point moves from the interior of the eye to the pole of the single refracting surface. The simple nodal point lies in the centre of curvature of the refracting surface, and the reduced eye is filled with only one refracting medium, and hence not provided with a lens.

Let us consider the eye as filled with a refracting medium whose index is $n_2 = 1.3365$, which is an arbitrary presumption, and the distance between the two focal points as equal to the sum of the two focal distances, which we will designate as S, the radius of this eye is computed according to the following formula: $r = \frac{S(n_2 - n_1)}{n_1 + n_2}$. Since we have found that $S = 13.7451 + 22.82361 = 36.56871$, therefore

$$r = \frac{36.5.. \times 0.3365}{2.3365} = 5.2665828,$$

we would then have

$F_1 = \frac{5.266..}{0.3365} = 15.65106$, and $F_2 = F_1 + F_1 r = 20,91765$, and $F_1 + F = 36.56871$, as above.

It is quite evident that the ideal total index of refraction of the eye, 1.3365, is not only arbitrary but insufficient for the reduced eye. Even if granted that the indices of refraction of the cornea, the vitreous and aqueous humors are equal and correspond to the value assumed, we have still to add the index of the lens. If we adhere to 1.3365 as the total index, the disparity can only be compensated for by the diminution of the corneal radius and of the axis, if we continue to reckon $S = 36.5$. We have as our result 5.26... for the radius, and 20.9... for the length of the axis, which are impracticable for computation of anomalies of the radius and axis, aside from the inconvenience of numerous decimals with which one has to deal.

To do away with the latter hindrance, *Donders* advised in favor of rounding off the figures and to assume the index at $\frac{4}{3}$ and the radius at 5 mm., whereupon $\frac{F_2}{F_1} = \frac{20}{15}$, and the length of axis would $= 20$. Computations with an eye thus reduced are certainly very convenient, and for that reason the proposition was received with great favor, and in so far adopted that for the last ten years most of the calculations on anomalies have been based upon the eye of $\frac{20}{15}$. Such an eye, however, affords only a miniature picture of the actual relations.

The corneal curvature is at least 2 mm. too small, the axis is too small by more than 2 mm., the centre of curvature of the cornea is too near, and above all, the total index is not less than it should be. This latter, with the addition of the lens, must be assumed as greater than 1.3333, greater even than 1.3365, at least 1.4371, and nearly equal to 1.5, through which latter assumption n_2 would $= \frac{3}{2}$, or about $\frac{1}{16}$ greater than $\frac{4}{3}$. It is very desirable to construct a reduced eye for the purpose of the computations of errors of refraction, whose corneal radius as well as axial length will correspond to the normal conditions.

Such an eye with $n_2 = \frac{3}{2}$ and a radius of 7.5 would have $\frac{F_2}{F_1} = \frac{22.5}{15}$ and an axial length of 22.5. The anterior principal focal distance corresponds to that proposed by *Donders*, the nodal point likewise remains 15 from the retina, the refractive power of the eye is still $\frac{1}{15}$, and only the posterior principal focal distance would be greater, equal to the normal length of the axis. The formula for this eye would therefore be $\frac{2}{f_1} + \frac{3}{f_2} = \frac{1}{7.5}$ or $\frac{1}{f_1} + \frac{3}{2f_2} = \frac{1}{15}$. For $f_1 = \frac{1}{\infty}$, the accommodation being entirely at rest, and the length of the axis being 22.5, we obtain $\frac{1}{\infty} + \frac{1}{15} = \frac{1}{15}$. This eye has the same power of refraction as that assumed by *Donders*, and differs only in that the distance at which images are formed increases a little more rapidly.

On account of the variation in construction of emmetropic eyes, other values may be introduced. We, therefore, append a table of emmetropic reduced eyes with radii varying from 7 to 8, the radius of each eye increased by $\frac{1}{10}$ with the corresponding focal distances, the values of S, F_1, and F_2; $n_2 = \frac{3}{2}$, being assumed.

$r = 7.$	$\frac{F_2}{F_1} = \frac{21}{14}$	$S = 35.$	$F_1 F_2 = 294$
7.1	$\frac{21.3}{14.2}$	35.5	302.46
7.2	$\frac{21.6}{14.4}$	36.	311.04
7.3	$\frac{21.9}{14.6}$	36.05	319.74
7.4	$\frac{22.2}{14.8}$	37.	328.56
7.5	$\frac{22.5}{15.}$	37.05	337.5
7.6	$\frac{22.8}{15.2}$	38.	346.56
7.7	$\frac{23.1}{15.4}$	38.5	355.74

7.8	$\frac{23.4}{15.6}$	39.	365.04
7.9	$\frac{23.7}{15.8}$	39.5	374.46
8.	$\frac{24}{16}$	40.	384.

The eye of $\frac{22.5}{15}$ evidently is the one offering the best average relations. The difference of the focal distance amounts to the radius of 7.5. The relation of the focal distances is $\frac{3}{2}$; the radius is $\frac{F_1}{2}=\frac{F_2}{3}$. The latter holds for each of the eleven emmetropic eyes which have been represented in the table. On the other hand, if we assume that $n_2=\frac{4}{3}$, or even that it is $=1.3365$, the radius will always remain far below the mean. For as soon as $S=39$, r must be $=5.61$, and $\frac{F_2}{F_1}$ must become equivalent to $22\frac{2}{16.6}$. F_1 rises too rapidly, and F_2 too slowly with an increasing S.

In computing the focal distances, all depends upon the imaginary total index, which must be assumed as greater than 1.3365, if an agreement is desired between the focal distances, the actual values of the optical axis, and the radius of emmetropic eyes. Better results are obtained if the total index be increased to that of the lens, to 1.4371 for example; we will then have $S=40.5$, $r=7.2$, and a relation of the focal distances of $\frac{23.89}{16.6}$. Even in this case r remains considerably below the mean, while the axis has widely exceeded the mean, and F_1F_2 is $=396.8$.

Hence, I feel justified in introducing the reduced emmetropic eye of $n_2=\frac{3}{2}$, and accordingly recommend that one of $\frac{22.5}{15}$, although under certain circumstances each of the eleven forms of emmetropia may be available. We should not forget that to each reduced eye there corresponds one which is schematic, which may be evolved from it, and the converse. The radius of the cornea, the length of the axis, the loci of anterior and posterior focal points, particularly the focal distances, must be identical in both eyes. On the other hand, the loci of the anterior and posterior focal points in the reduced eye are of equal value to the anterior and posterior focal distances, whereas in the schematic eye the anterior focal distance is the sum of the locus of the (anterior) focal point and the anterior principal point; and the posterior focal distance is the difference between the loci of the posterior focal point and posterior principal point.

He who thinks it incumbent on him to be thus accurate, may compute the schematic eye from the corresponding reduced one. He should not, however, forget that even here he will not be able to avoid some forced assumptions and errors. For the calculation of errors of refraction in every-day life, we must employ under all circumstances a reduced eye of mean dimensions, whose values may be expressed as nearly as possible in round numbers that may be easily manipulated, and in which the corneal radius, as well as the length of the axis, does not deviate widely from the mean.

The reconciliation of theory and practice must be our constant aim. This object is, however, not to be obtained unless concessions are made upon both sides, upon the side of theory as well as practice. This holds good also in the introduction of the reduced, so-called school eye. The total index of the phakial eye of mean dimensions is more nearly comparable to that of glass than to that of distilled water.

The foregoing lines—if in conclusion I may express their contents in one word—contain the proposition to consider the reduced eye as filled with glass instead of distilled water.

PRAGUE, January 17th, 1878.

AMBLYOPIA AND PARALYSIS OF THE OCULAR MUSCLES IN DIABETES.

By Prof. Dr. HERMANN COHN, in Breslau.

Translated by Edward Fridenberg, M.D., of New York.

From Theodor Leber's excellent memoir "On Diseases of the Eye in Diabetes Mellitus" (Graefe's Archiv, xxi., 3, pp. 206–337), we learn that disturbances of vision in glycosuria have already been observed by Rollo (Cases of the Diabetes Mellitus, 2d Ed., London, 1798). Since his time all cases of asthenopia in which cataract could not be diagnosticated were classed under the head of amblyopia, especially in France, until about the year 1850, after the introduction of more accurate methods of examination, many of these so-called cases of diabetic amblyopia were found to be dependent simply on paralysis of accommodation. V. Graefe did not believe in the existence of diabetic amblyopia, as in most cases brought to him with this diagnosis he had found paralysis of accommodation, and in this subject his authority, as Leber remarks, has, exceptionally, retarded instead of furthering our knowledge. Retinitis diabetica, hemorrhage into the vitreous, atrophy of the optic nerve—all these conditions have been observed since, but ophthalmologists have not described a single case of amblyopia without ophthalmoscopic changes or paralysis of accommodation. Leber, besides collecting and classifying with the greatest care the older literature, was the first to prove the existence of amblyopia and paralysis of ocular muscles due to diabetes.

As early as in 1868 I had sent an unmistakable case of amblyopia to Dr. Seegen in Carlsbad (see below Case I.), which he briefly notices as No. 114 in the second edition of his book "On Diabetes Mellitus" (page 320). Leber also states expressly that the first *authentic* case came from me, but in order to get similar cases for comparison, I did not publish it at the time.

Seegen (Case 131, p. 330) mentions in brief that Bowman had sent him a lady whose vision had been gradually growing worse for two years, without any changes observable with the ophthalmoscope, and that in another patient in whom sight had decreased suddenly, v. Graefe had found no ophthalmoscopic changes.

In Mooren's "Ophthalmiatr. Beobachtungen" (1867, page 20) Leber found two cases of bilateral amblyopia in diabetes recorded in the tabular statement, and a similar case in Mooren's Report of 1873. Particulars are wanting.

In "Steffan's Jahresbericht" we find two similar cases in which the visual field was preserved.

A short notice of Colsmann (Berl. Klin. Wochenschr., 1870, page 386, c. 14) is cited by Leber. There is no mention of the visual field.

Leber has given us a very accurate description of three cases of amblyopia diabetica, one with defect of the visual field, another with hemiopia, a third with central color-scotoma.

Since this time, *i. e.*, 1875, to the best of my knowledge, only one case has been published. This case, a lady aged sixty-two, came to Foerster, her right eye having become blind suddenly one week previously (Foerster: Relation of Affections of the Eye to Constitutional Diseases. Graefe-Saemisch: Handbuch, vii., 1, p. 222). Fundus and media appeared normal; the urine contained a large amount of sugar; the left eye was sound; one month later the right disc became paler. Of all the cases reported, Foerster accepts only those of Leber.

Leber, having searched the records carefully for paralysis of ocular muscles in diabetes, found frequent mention of double images; whilst paralysis proper was only reported in four cases.

In the first case, reported by Ogle (On Disease of the Brain as a Result of Diabetes. St. George's Hosp. Rep., Vol. I., p. 157–188), paralysis of the oculomotory nerve, diabetes, and foci of softening in the cerebral hemispheres, were found. The second case, that of a diabetic patient who had an apoplectic attack, is reported by Schneller (Studies on the Visual Field. Graefe's Arch., xxi., 3). In this case there was a paralysis of the inferior rectus on the right, of the internal rectus on the left side. In a third case, of Leudet (de L'influence des Maladies Cérébrales sur la Production du Diabète. Moniteur des Hôp., 1857, page 254), the left eye was blind, and both the trigeminus and oculomotorius paralyzed. In the fourth case, of Schaper (Inaug. Diss., Goettingen, 1873), that of a man who became subject to diabetes after being struck on the head by a stone, there was a complete paralysis of the abducens on the right side. At the autopsy no changes could be detected in the floor of the fourth ventricle, nor were there any signs of fracture.

Neither Leber nor Foerster have seen paralyses, and as Alfred Graefe does not even mention diabetes as one of the causes of paralysis of the ocular muscles (Graefe-Saemisch's Handb. d. Augenkrankh., vi., 2), these cases must be very rare.

Having, as above mentioned, found a case of amblyopia diabetica as early as in 1868, I entered this disease on my schedule of questions in 1873 (Leber's paper appeared in 1875). In 1874 my questions were answered by 27 institutions, with 90,510 specified cases. Among these, amblyopia diabetica is found in four cases, one of Woinow, one of Prof. Rydel in Krakau, two of my own; one of the latter, S. $\frac{1}{2}$, with myopic astigmatism in a diabetic patient, even being doubtful.

In 1875, 35 institutions answered my questions. Among 95,125 specified cases, amblyopia diabetica occurred once only, in a case of Dr. Just in Zittau.

Among 200,000 cases of diseases of the eye observed during two years, a positive diagnosis of diabetic amblyopia was only made four times.

Some cases of diabetes occurring in my own family, and this disease arousing a special interest in me, I have for ten years examined the urine in almost every case of amblyopia. Still among 21,000 patients, I have only made the diagnosis in six cases, in four of which I was led to the diagnosis by the amblyopia alone. Two of the cases were complicated by paralysis of the ocular muscles. I think I am justified in communicating these cases on account of their rarity:

Case I.—Mr. Gillert, a teacher, aged 38, somewhat emaciated, consulted me on the 18th day of June, 1878, for weakness of sight, which was increasing steadily. He complains of nothing else, and states that formerly he possessed excellent eyes. The right eye reads letters of Snellen 3 at 10–12″ with difficulty. With + 10 (inch system) he can just read $2\frac{1}{2}$. The left eye reads 3 from 8–30″, $1\frac{1}{2}$ with difficulty from 10–16″. With + 10: $1\frac{1}{2}$ from 3–9″. Right eye S. $= \frac{1}{3}$, left eye S. $= \frac{5}{6}$. Visual field complete on either side; pupillary reaction perfect; on ophthalmoscopic examination no abnormality whatever; lens clear. On the right side, the veins seem to be somewhat fuller than on the left, but the difference is hardly perceptible. The patient does not stagger when standing with his eyes closed. (The sensitiveness of the retina to red was not examined.) Not being able to account for the amblyopia, I examined the urine, which contained seven per cent of sugar. After a prolonged cross-examination of the patient, he at last mentioned that a year ago he had been treated for corpulence after Banting's method, and that for six months his appetite and thirst had increased. The sexual powers are intact, and he looks quite strong. He gives no history of venereal trouble. I immediately sent him to Prof. Seegen at Carlsbad. After five weeks' treatment he was discharged; his urine had diminished in quantity from 3300 cc. to 1190 cc. daily, and contained two per cent instead of seven per cent of sugar. On the 8th of August, the right eye read 2 from 9–12″ without a glass, with + 10 $1\frac{1}{2}$ from 6–8″. S. was almost normal; in the left eye it was perfect, $= 1$. I prescribed arsenic, which was much recommended at the time, with the effect of increasing his weight a few pounds. In April, 1869, his sight proved to be the same as in August of the year before. In the summer he returned to Carlsbad, and I read a notice of his death in the papers in the same year.

Case II.—Mr. Gaehl, aged 40, a merchant, came to my clinic on July 21st, 1870. The left eye presented a soft cataract, and could not count fingers. With the right he could hardly read 3 from 8–10″. With + 10 $1\frac{1}{2}$ was read with difficulty at a distance of 4–5″. M. $\frac{1}{10}$ and S. $\frac{15}{30}$. *Media, visual field, and fundus perfectly normal.* Patient came to me with the diagnosis diabetes. Three years ago, he had a carbuncle on the right pectoralis muscle, and increase of thirst. These symptoms led his physician to the examination of the urine, and diabetes being found, he was sent to Carlsbad, where he improved temporarily. He never had syphilis. The patient is emaciated, especially about the face and the chest. During the night, he passes 3–4 quarts of urine, notwithstanding which, he sleeps well. The teeth are sound; there is no odor of apples from the mouth. Specific gravity of urine =1037, sugar eight per cent (Prof. Gscheidlen). I did not see the patient again.

Case III.—Mr. Biedermann, from Glogau, a bookkeeper, aged 48, thin and weakly, consulted me on January 11th, 1877, for increasing "shortsightedness," without being aware of his disease. He reads Snellen 1.25 with either eye, with +6 no improvement. M. 6 and S. $\frac{3}{60}$ in both eyes. Even after the use of atropine, nothing abnormal is to be found, except the myopic conformation and a small crescent. Perimeter entirely normal for both eyes, but in the centre red appears brownish, and the simultaneous contrast of gray rings on green paper under tissue paper is called bluish instead of red; other colors are perceived correctly. Proceeding to examine in the upright image and approaching the patient, I noticed the acetone smell from his mouth. The urine was examined immediately. Sp. gr. 1033, five per cent of sugar (Druggist Mueller). The patient now also complains of deficient vision, and states that he has noticed polyuria, increased thirst, and impotency during the last year. No history of syphilis. Carlsbad water, prescribed immediately, did not materially improve his condition. The amount of sugar decreased about one-fifth, the amblyopia remained the same; but red was now correctly seen in the centre. Four weeks later, there was M. 6, S. $\frac{6}{30}$ as before. No improvement from the use of carbolic acid or from the springs at Carlsbad. He sank rapidly and left Carlsbad, as Dr. Wollner, to whom I had recommended him, wrote, in a hopeless condition.

The examination in the inverted image does not necessitate such a near approximation to patients as the one in the upright image. It is, hence, to be preferred according to Schmidt-Rimpler, as by it we avoid the foul smell issuing from the mouth of uncleanly individuals. In this case, however, as well as in the following, it was just the necessity of approximation which led to the detection of the acetonic odor and of diabetes itself.

CASE IV.—Mr. Golob, from Turek in Poland, a merchant, aged 58, came to me in November, 1876, with slight mydriasis and traumatic cataract in the right eye, caused by the impact of a cork from a soda-water bottle six weeks previously; since that time he had been under Szocalski's treatment. S. $\frac{10}{200}$, words of 4.0 are read with +6. Visual field and appreciation of colors perfect. Though he only complained of this eye, I also examined the left eye, finding E. with S. $\frac{50}{70}$; the eye reads 0.5 with +4.0 D. Fundus and media perfectly normal. Patient states that his eyesight it as good as it ever was. According to Donders and de Haan, S. $\frac{5}{7}$ in a patient almost 60 years old would be physiological, as they compute S. $\frac{14}{20}$ for this age. Notwithstanding this, I ought to have been struck by this amblyopia. For in my examinations of one hundred persons, in Schreiberhau, 60–85 years old, I had found S. > 1 in 88, S. $= 1$ in 34 and S. < 1 in 10 eyes only, without pathological changes (Tagbl. der 47. Naturforscher-Versammlung zu Breslau, 1874, page 106).

Unluckily I did not investigate the amblyopia, but advised the patient to wait until the cataract had matured, and then to return for an operation.

The same thing happened to an estimable confrère in Berlin, whom the patient consulted a few days later. He also noticed amblyopia in the left eye without paying further attention to it. On August 6th, 1877, *i.e.*, nine months later, Golob returned to find out whether the cataract in the right eye was ripe or not. Examining in the upright image I found everything normal. But perceiving the odor of acetone from the mouth, I tested the urine, which weighed 1035 and contained 5 per cent of sugar. In this case also, as I now was told, slight symptoms of diabetes had been noticed for one year. Patient had the appearance of a perfectly healthy man, and no oculist can be expected to examine the urine in a case of traumatic cataract. After repeated questioning, patient also remembered that one year ago he had seen double during a few weeks, but he could not recall the exact position of the double images. At the same time he had suffered from increase of thirst, and some months before had been treated for an anthrax on the left upper arm. Diabetes had, notwithstanding, never been diagnosticated. No trace of syphilis. He now reads letters of 1.5 with +4.0, but not without difficulty. S. $\frac{5}{7}$ has been retained, but *E. has become M.* 2.

I can offer no explanation for this increase of refraction. It could hardly be a sign of commencing cataract, as I found the lens absolutely clear. Horner, on the contrary, has observed a diminution of H. from $\frac{1}{14}$ to $\frac{1}{48}$ coincident with the disappearance of the sugar in a diabetic woman using Carlsbad water. He believes that the increase and decrease of the hyperopia depends on the increase or diminution of the contents of the globe. In Case V. (see below) we have an analogue to Horner's case, which had been the only one of the kind recorded hitherto.

As soon as the disease was discovered, the patient was sent to Carlsbad, where the sugar disappeared entirely, and as Dr. Wollner has written to me, the patient when discharged could read the finest newspaper-print with his glass + 2 D. The state of refraction was not examined at Carlsbad, but I hope to see the patient again, and to be able to fill this gap.

Case V.—Mrs. Kessler from Glatz, aged 68, weighing 220 lbs., very stout, consulted me in March, 1874, for increasing weakness of sight. Some weeks previous she had suffered a sudden obscuration of vision on the street and had to be conducted home by strangers. She saw all objects double, but does not remember the position of the double images. At present there is no paralysis, no double images, but the patient *bends her head forwards* in order to see better—a manœuvre the cause of which I am unable to detect, and complains of constant headache. *Visual field* as tested by the perimeter *normal; no central scotoma.* Reaction of pupils, appreciation of colors and of light perfect. Nothing but amblyopia in the right eye H. 1.75, S. $\frac{5}{7}$; + 4 D.: 0.6 smallest print; in the left eye H. 1.5, S. $\frac{5}{10}$; + 4 D.: 1.0 smallest print.

No explanation for the amblyopia being found in the fundus or the media, the urine was examined. It weighed 1030 and contained 5 per cent of sugar. On cross examination we get a history of thirst, insomnia, and loosening of the teeth. She states that a few drops of her urine having fallen on an embroidered ottoman, some days later she noticed on it a number of sticky spots. No syphilis. Karlsbader Muehlspring was prescribed, and during its use at home the obscurations of vision and double images recurred once. In June, 1874, when I next saw her, she had lost 52 lbs. under treatment; the urine contained *sugar* and *albumen.* The equators of both lenses were slightly turbid; the centres clear, the amblyopia unchanged. In August, 1875, *i. e.*, $1\frac{1}{2}$ years later, she could not count fingers in the infero-nasal quadrants of both visual fields. The obscurations of vision recurring from time to time were not due to paralysis of accommodation, for during them even the use of a strong lens did not enable her to read. In September, 1876, the patient had lost 74 lbs., looked still somewhat bloated, and bent the head forwards while walking. In the right eye, the nucleus of the lens is already cloudy, S. $\frac{1}{20}$. In the left eye, the centre of the lens is still clear, but H. $=3$ D. and S. $\frac{1}{5}$. With $+6$ words of 0.6 are read. Thus during the disease H. has increased from H. 1.5 to H. 3, as in Horner's case.

The general health of the patient was failing rapidly, and in Oct., 1877, as her physician wrote, she died with œdematous effusions. An autopsy was not held.

Case VI.—Eliza K., aged 55, wife of a merchant, very stout, came to me in December, 1872, with a complete traumatic paralysis of the abducens. Five years before she had had an apoplectic attack with right hemiplegia and paralysis of the tongue. Ten days ago she struck the right temporal bone against the sharp corner of a bureau with great force, three hours after which she became subject to distressing double sight. In both eyes M. 4 and S. $\frac{50}{70}$; ophthalmoscopic examination negative, *i. e.*, amblyopia, to which unluckily I paid no further attention.

She was treated with bromine and electricity by Dr. Berger, the paralysis disappearing within three months. Five years later, July, 1877, the patient returned with *complete paralysis of the left abducens.* She had been suffering from thirst and sleeplessness for six years, diabetes being diagnosticated by her physician a short time after the first abducens-paralysis. She has been drinking Carlsbad springs every year, always with a temporary improvement, and at present takes the water for four out of every eight weeks at 2, 4, and 6 A.M.; this method giving her most sleep. The patient is still very stout. There is nothing left of the old paralysis of the abducens. Two days ago she had an attack of headache with vomiting, and on awaking yesterday morning the abducens of the left side was found to be completely paralyzed. Media and nerve are entirely normal. There is no sign of cataract. The entire left side of the head is painful on percussion, the right side is normal. On the right side M. 4, S. $\frac{1}{2}$; on the left M. 5, S. $\frac{1}{2}$; *i. e.*, considerable increase of amblyopia. The patient was immediately sent to Carlsbad, where she remained under Dr. Wollner's treatment until October. Her weight decreased from 185 lbs. to 170 lbs.; she looks healthy, thirst and pruritis vulvæ are gone, sugar decreased from 5 per cent to 0.3 per cent; sp. gr. of urine 1020. The paralysis of the abducens, however, has persisted, the double images being as distressing and as far apart as ever. On the right side, M. 4 and S. $\frac{1}{5}$; on the left, M. 5 and S. $\frac{1}{4}$; *here again* the amblyopia has become much worse. Fundus and media are normal. Visual field is normal in both eyes for white; for red it is intact in the right eye, while in the left red is perceived as a dull bluish-red. 1, in the centre; 2, upwards from the central point of fixation to 10°, thence going around to the right from 30 to 30°, corresponding with the following numbers on the dial: 8, 5, 20; 17, 8, 5; 2, 2, 18; 18, 15, 10°. The optic nerve is absolutely normal and without any discoloration whatever—a fact of which I have again convinced myself a few days ago.

My conclusions drawn from these observations are as follows:

1. In every case of amblyopia and of paralysis of the ocular muscles the urine ought to be examined. We may, it is true, not find sugar in hundreds of cases, but a single case, if overlooked, will surely be regretted. In four cases out of six I have detected the disease through the amblyopia. *Leber* and *Foerster* also insist on the examination of the urine as a matter of routine.
2. The appearance of the patient is often such as not to give rise to the suspicion of diabetes, and still diabetic amblyopia may already exist.
3. In all cases of amblyopia, the disease has reached an advanced stage, as the morning-urine already contains sugar.
4. In one case the refraction diminished during the disease (H. 1.5 to H. 3); in another case it increased (E. to M. 2).
5. In all cases the amblyopia had invaded both eyes, though not to the same degree, and had always arisen slowly and insidiously.
6. The visual field, examined in every case, was found normal in five cases. In one case both eyes were the seat of a defect downwards and inwards.
7. The sensation of red in the centre was slightly deficient

in two cases. In one case this deficiency was cured in Carlsbad without a diminution of the amblyopia.

8. The amblyopia improved at Carlsbad in two cases, remaining stationary in one case, and becoming worse in two.

9. Paralyses of ocular muscles of diabetic origin are perfectly curable. Foerster supposes that these paralyses are caused by extravasation of blood into the nerve-sheaths. This seems probable, but I would like to call attention to the fact that the *central* origin of all the nerves distributed to the ocular muscles is situated in that portion of the cerebrum forming the floor of the aqueduct of Silvius, of the fourth ventricle, and the adjacent parts.

10. In certain conditions Carlsbad Muehlspring can be taken with benefit during the night as a hypnotic.

POSTSCRIPT.

While this paper was already in the hands of the editor, I had the opportunity of observing the following very instructive case:

On December 1st, 1877, I received a letter from a lady to the effect that her husband, who would call on me the next day, was ruining himself and his family by an immoderate use of spirituous liquors. She besought me to speak earnestly to her husband, as his eyesight was becoming steadily worse, and this was undoubtedly due to his drinking. On the next day, the patient, A. G., director of a factory in Hirschberg, came to consult me. On October 16th, 1875, *i. e.*, two years before, I had performed Jaeger's operation for cataract on his left eye with a good result. As early as September, 1873, I had found beginning cataract in both eyes, more advanced in the left, and also noted that his wife informed me privately of her husband drinking beer in large quantities. At the time, his hands, when stretched out, would shake. The operation was typical throughout, so that the patient was discharged, without any irritability of the eye, on the ninth day. He correctly read Snellen 0.8 with +18.0, and with +10.0 S. was $\frac{14}{200}$. Four weeks later, I made a discission of the secondary cataract, when he read Sn. 0.5 easily, being discharged with S. $\frac{50}{200}$. Nerve and retina were absolutely normal.

On his return now, in December, 1877, he states that since a short time, while the cataract in the right eye was maturing, the sight of the left eye, excellent after the operation, was declining slowly but surely. Media, nerve, and retina entirely normal. With + 20.0 he can hardly recognize letters of 1.6. With + 11.0 S. is about $\frac{1}{30}$. Visual field perfectly normal for white and red. Sensitiveness to red in the centre of the perimeter not at all depreciated. He does not recognize a pink shadow on a green background when his sight is tested for colored shadows, calling both dark; but he reads red on green from Stilling's table of colors correctly, and though unable to read red on brown (as is often the case with normal eyes), he appreciates the color of each square. The patient, instead of looking weak or bloated, is the picture of a strong, robust, muscular man. His face has the color of perfect health, he feels well, but when he stretches out his arms they tremble somewhat. Very much surprised at not finding the central visual defect for red, which is present in most drinkers, I examined the urine, *which contained* 5.1 *per cent of sugar and weighed* 1035. In spite of this, there is no insomnia, no increase of appetite, no loss of sexual power. The patient was treated by me and by Dr. Wollner. The diet was regulated, and carbolic acid prescribed. Yesterday (January 10th, 1878) he sent me a specimen of his urine, in which there is not a trace of sugar. I have not yet been able to examine his eye again, but he states that his sight has remained exactly "in statu quo ante," not getting any better nor any worse.

This case is also one of amblyopia diabetica proper. As he did not recognize the contrast color for green, we are not able to exclude a gradual atrophy of the optic nerve in the future.

CONTRIBUTIONS TO THE PATHOLOGICAL ANATOMY OF THE EYE.

By Prof. SCHOTT, of Innsbruck.

(See Plate III.)

Translated by J. Kinkead, M.D., of New York.

A. *Communications on the Diseases of the Optic Nerve.**

3. Glio-sarcoma of the Optic Nerve.

On 6th of March, there was sent to me by Prof. Mauthner for examination a tumor which had been removed by an operation from the right orbit of a child five years old. The history of the disease and the opinion of the case were published by Prof. Mauthner in the Vienna Med. Press, Nos. 4–5, 1878, in his article upon "Exophthalmia." He says:

"Very interesting, therefore, in many respects, was the case of the girl, A. P., æt. 3¼ years, who presented herself at my clinic on March 5th, 1877, with the following symptoms: the right eyeball protrudes about 7 mm., and is directed somewhat upwards and inwards; the upper eyelid is enlarged and traversed by dilated vessels; the tension of the globe is not increased; the conjunctiva is pervaded by a scanty network of veins; the refractive media clear; the cornea sensitive; the pupil is irresponsive to light, but acts promptly in synergy with the other; in the direction of the optic nerve, the eye is hypermetropic ⅕ (which represents a shortening of about 2 mm. in the normal eye); the papilla of the optic nerve is of a greenish tint, yet still showing a slight reddish gleam in the centre, with its medial border indistinct; the arteries and veins are large on the papilla, and tortuous in their course over the retina; in the inner-lower quadrant of the nerve-entrance, a thick vein appears to project like a loop in the vitreous humor; the retina gives remarkably strong reflections along and between the vessels;

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* See these Archives.

the mobility of the eye is not diminished; the eye, the pupil of which is insensible to the changes of light, does not follow a candle when the left eye is closed, and consequently is amaurotic. If the finger is pressed deeply against the eyeball, through the upper lid, no tumor can be discovered; but if the pressure be made from below and outwards, towards the posterior pole of the globe, a strongly resisting tumor can be reached.

The parents of the child say that, as far as they can remember, she has always been healthy, and that the gradual enlargement of the right eye, unaccompanied by pain, has been noticed for two years. I may say, however, that I had seen the child several weeks before she presented herself at my clinic, and her condition was then the same as described above. The diagnosis of a genuine tumor of the optic nerve was then made. The slow development of the growth, the free mobility of the eye, and the total blindness of one side, though the degree of exophthalmus was not great, justified the diagnosis. The fact that the eye did not project in the direction of the axis of the optic nerve, as v. Gräfe had observed to be the case with such tumors, nor outwards, but on the contrary, upwards and inwards, was explained by the fact that the growth could only be felt by pressing from below and outwards. The tumor of the optic nerve must, therefore, have grown luxuriantly almost or entirely in this direction (not that of the axis), and consequently the eye was pushed forwards, upwards, and inwards. The first time I saw the child, I suspected there might be a tumor of the brain to complicate the case. The child's skull was normally developed, there was no pain on percussion with the finger, and the parents asserted that the child had not only developed well intellectually, but had always been physically healthy. Nevertheless it was possible there might be a tumor of the brain; but such tumors usually produce swelling of both optic papillæ. Had the ophthalmoscope shown swelling of the papilla in the left eye, in which the parents had at no time observed a diminution of sight, then, under such circumstances, the diagnosis of a brain tumor would have been confirmed. The ophthalmoscope only shows a papilla which is not entirely normal, slight tortuosity of the vessels (both veins and arteries), slight paleness of the nerve, and an outline less sharply defined than usually, but absolutely no swelling; on the whole, the condition was not decidedly pathological. Yet, before deciding upon an operation, I determined to have the child carefully watched for some weeks, both by the attending physician and my assistant. Not until I was convinced by the lapse of time that the disease showed no symptoms which could arise from a tumor of the brain, and especially as the child was then perfectly well, did I resolve upon an operation.

We have stated in Case I. (which described a cavernous tumor in the funnel-shaped space formed by the four recti) that removal of tumors inclosed by the recti muscles should not be preceded by enucleation of the globe, but that the globe should be preserved. In the case of this child, the tumor was likewise inclosed by the recti muscles, but it originated in the optic nerve itself. Yet Knapp (1874), in a similar case, designedly extirpated only the degenerated portion of the nerve and preserved the globe; and a second time the same operation was successfully performed by Grüning (1875). I also undertook to remove the tumor without the globe.

On March 6th, 1877, the operation was performed under an anæsthetic. After incising the skin, I began by inserting a thread, armed with a needle at each end, through the tendon of the rectus internus, and then divided this muscle close to the eye. I believe the operation for extirpation of a tumor of the optic nerve should always be begun by dividing the rectus (lateral or median), in order to secure the requisite space to work in. Knapp completed his operation without dividing any muscle, but his difficulties were thereby greatly increased, and Grüning unintentionally cut through the belly of the internus.

I then introduced the little finger to separate the nearest portion of the tumor from the surrounding tissues, but the space was too small. So I divided the growth (the optic nerve) at first close to the globe with the scissors, and pressed the eye to the temporal side. The tumor, which entirely filled the back portion of the orbit, was easily freed from its surroundings by the little finger; a tenotome was slid along the index finger of the left hand to the optic foramen, the optic nerve cut short off with one stroke at its entrance, and the tumor lifted out. There was very slight hemorrhage. The eye was replaced, and the internal rectus reunited with sutures. On account of an irregular abrasion of the epithelium, even after moistening the cornea, an ophthalmoscopic examination, made immediately after the operation, gave no result. A uniform illumination of the fundus was obtained, but no details were discernible.

The eye projected considerably, yet it was possible to close the lids over it.

The history after the operation was as follows:

March 6th.—One hour after the operation, a slight swelling appeared in the temporal region and on the right cheek; a few drops of blood flowed from the nose. In the evening, the bleeding from the nose was repeated, the swelling of the cheek had increased, and felt hard without redness or increased local heat. Temperature 39°. The child had not fully recovered consciousness since the operation, and slept with interruptions.

March 7th, 10 A.M.—When the bandages were removed, the globe appeared protruded, the palpebral fissure open, the lids slightly swollen, the cornea entirely clear with no trace of suppuration or sloughing. A purulent discharge escaped from the conjunctival sac by drawing the lower lid down. The bandages were left off, and the eye bathed with milk.

3 P.M.—Temp., 40°; P., 130. The child vomited once; slight twitching of the fingers; somnolent. The little patient answered questions put with a loud voice. Ice compresses were applied to the head.

7 P.M.—Temp., 39°. An effort was made to relieve the tension of the lids by slitting up the outer commissure, and through an opening into the orbit to give an exit to the retrobulbar contents. This proved impossible, however, as I failed to replace the globe. Enucleation was then performed to allow free exit to the pus and sanious fluids—a peculiar operation, enucleation of an eye without an optic nerve. The globe did not present—now thirty-four hours after the first operation—a single evidence of pus or necrosis.

March 8th.—Early in the morning the temperature stood 42°, pulse 140. The swelling of the cheek had diminished. The orbit was washed out with a five-per-cent solution of carbolic acid. An ichorous fluid, mixed with necrosed shreds, escaped. In the evening, the temperature had again fallen to 39.2°, pulse 120.

March 9th.—Temperature, 39.5°. She had chills.

March 10th.—Cheeks somewhat swollen, slight convulsions—temperature, 41°.

March 12th.—The patient took little nourishment, swallowed with difficulty, was constantly unconscious, and had spasmodic convulsions in the upper extremities. An ophthalmoscopic examination of the left eye was made at 7 P.M., but nothing important discovered.

Death occurred on March 13th, at 7 A.M., without any peculiar symptoms. I asserted before the autopsy that an intracranial disease, in particular a brain tumor, might exist, for even if the symptoms of the last days were to be attributed to a meningitis—although it never went so far as to slacken the pulse—still it was unintelligible why brain symptoms appeared immediately after the operation, for the intellect was never afterwards clear. It seemed probable, however, that the irritation caused by the severe operative injury in the vicinity of the optic foramen at once produced manifestations of an intracranial affection previously existing. The autopsy made by Prof. Schott confirmed my opinion. The observation is noteworthy,

1st. On account of the latency of the brain tumor, which in its first stage was possibly congenital, whilst the tumor on the orbital portion of the optic nerve may have developed after birth.

2d. On account of the absence of choked disc in the other eye.

3d. On account of the recent demonstration that removal of a tumor on the optic nerve without enucleation of the eyeball can be undertaken. Since the eyeball was preserved intact at the expiration of thirty-four hours, despite the unhealthy discharge from the tissue of the orbit, it is evident that the operative procedure as such (dividing all the vessels and nerves encountered in the posterior pole of the eye), would not have been followed by sloughing of the ball. That the sloughing of the orbital tissue was the result of not removing the eye with the tumor will scarcely be positively asserted by any one.

No one acquainted with the literature of the subject will deny the similarity of the preceding case to the one reported by v. Graefe in his Archives, Vol. XII., 2, 1866, page 100, under the title of "Tumor Orbitæ et Cerebri."

I have only had one other opportunity of observing an unmistakable tumor of the optic nerve. About ten years ago, a man in his thirtieth year was received at v. Jäger's eye clinic, with considerable exophthalmus of the right eye. The eye was about in its proper axis, pressed directly forwards, freely movable, amaurotic, and the ophthalmoscope showed atrophy of the optic nerve. Nowhere could the finger reach a retrobulbar tumor. It was evidently a spindle-shaped tumor of the optic nerve. The patient declined any operative procedure.

The number of tumors of the optic nerve on record is not yet very great, hardly amounting to two dozen. Moreover, not only are those recognized as tumors of the optic nerve which have their seat of origin in the nerves or their inner sheaths, but also those which spring from their outer sheaths.

The tumor of the optic nerve (Fig. 1) was kidney-shaped, was 28 mm. long, 20 mm. wide, and 19 mm. thick. Its surface appeared for the most part smooth, and was only partially attached to the fatty cellular tissue ; it felt tough and elastic, and had a grayish-red color. The optic nerve (*a*), thickened in its sheath and somewhat curved, entered the tumor from the posterior portion ; its length, from the posterior end of the tumor to its free, smooth, anterior end, was 10 mm. ; the connective-tissue capsule, enveloping the tumor, terminated in an irregular border-line (*b*) on the anterior portion of the tumor close to the eyeball. From its anterior surface, which was the size of a penny, there emanated a substance partly tough, partly soft, gelatinous, and shining, which was kept moist by a scanty amount of viscid fluid. In a section dividing the tumor in half, the tumor looked white, like brain-substance, the covering for about 1 mm. in width resembling a tortuous, flowing, gray streak, clearly separated into two layers, a peripheral (*a*) and a central (*b*) ; the first 8 mm., the latter 15 mm. wide. In both layers, and especially distinct on the posterior end of the tumor, appear many fissures, longer or shorter, and of different depths, which on the peripheral layer are placed perpendicularly to the central portion, on the central layer are parallel to the long diameter of the growth. By their frequent recurrence, portions of the two layers appear finely reticulated, especially distinct in the middle of the dividing section, from whence this appearance diminishes towards the anterior end of the growth, rendering manifest several irregular depressions separated by elevations, and produced by softening of the tissue.

The stump of the optic nerve is 7 mm. broad, its sheath 1–2 mm. thick, its cut surface homogeneous, and on it are seen two proportionately broad cross sections of vessels.

On examination with the magnifying glass, it is evident that the dura mater in particular is thickened, and the subdural space is filled with a soft pseudoplastic substance, arranged partly in concentric layers, which covers the surface of the optic nerve.

Microscopic examination of the delicate membrane found on the outside of the growth, which was partly folded and partly penetrated by cellular tissue, showed that this was composed of bundles of delicate connective-tissue fibres forming a coarse network, and which were connected by a membrane composed of partly parallel, partly reticulated filaments.

This could be easily separated from a firm underlying membrane, ½ mm. thick, which rested immediately upon the surface of the tumor, and consisted chiefly of parallel strips of undulating connective tissue, adhering so closely to the underlying mass of the tumor that it could not be separated from it.

Fresh sections of the tumor, examined in iodine serum, showed cells both isolated and partly connected with each other.

The isolated cells (Fig. 3, 320 diam.) show divers shapes, being either round, irregular, or stellate; their protoplasm is finely granular, and contains in some isolated cells distinct fat molecules (*a*). The nuclei appear large, mostly oval, and have distinct nucleoli; some of these are dividing (*b*). The cell processes are unusually long, and there is either only one (*c*) or two (*d*) of them projecting in opposite directions from the protoplasm, or there may be several (5–7); in such cells it is surprising that there is always one of the prolongations distinguished by a remarkable thickness and a spirally twisted course.

All these cells display an analogy to ganglionic cells, although it is impossible, by the means employed, or by our knowledge of the afferent nerve-fibres, to give any proof for such belief.

A small portion of the new growth, laid in Müller's fluid for thirty-six hours, and then treated by maceration with distilled water, gave the following constituents (Fig. 4):

(1.) Small round cells, the size of white blood-corpuscles with granular protoplasm and an indistinct nucleus (*a*).

(2.) Somewhat larger, irregularly shaped cells, supplied with a distinct, quite large nucleus, and a short, fine, somewhat curved process (*b*).

(3.) In the greater number we see stellate cells (*c*), which are either spindle-shaped, having two remarkably long, somewhat spirally twisted processes growing in opposite directions (*d*), or more commonly with several processes, amongst which, however, many are distinguished alike by their remarkable length, spiral twisting, and subdivisions. The body of the above-mentioned cells appears either oblong, spindle-shaped, polygonal, or irregularly triangular and strikingly flat (*c*). The protoplasm is finely granular, the nucleus round or oval, also granular; here and there are to be recognized the first traces of a division of the nucleus (*e*); some cells can be distinctly seen to anastomose by their delicate offsets.

For the purpose of making large sections, the extirpated growth was hardened in Müller's fluid.

A longitudinal section through the axis of the optic nerve, extending some distance into the tumor, appears perfectly homogeneous, surrounded at the periphery by a delicate double border line (Fig. 5, *a*), and materially different from the preceding section of the tumor, which was obtained from a portion of the fresh specimen, situated on the side of the entrance of the optic nerve, and which presented, as before stated, two distinct, in part finely reticulated layers.

Microscopic examination of sections taken from different parts gives, with a power of 320 diameters, stellate nucleated cells, which, by juxtaposition, superposition, and anastomosis, form a delicate network, which is here and there interrupted by apparently cellular tracts of fibres (denser agglomerations of more elongated cells) running in different directions.

The cross section of the stump of the optic nerve (Fig. 6), examined microscopically, shows the sheath of the nerve remarkably thickened, its fibrous tissue studded with numerous nucleated, mostly uniform round or oval cells, and corpuscles with concentric layers; also traversed by vessels irregularly enlarged and engorged with blood, most of which, at the periphery, are directed perpendicularly to the surface of the nerve, encircling the trunk of the nerve in a somewhat winding course, and between these two points, as many existing sections show, appear to run either in an ascending direction, *i. e.*, longitudinally to the trunk of the nerve, or, under the form of repeated curves, cut through transversely.

The interstitial connective tissue of the nerve is likewise thickened, so that its principal tracts appear like broad bands, richly covered with cells, sending a network of delicate nucleated cells into the nerve-substance, the latter showing an attenuation of its fibres.

While I was occupied with a partial examination of the tumor, the death of the little patient occurred, seven days after the operation, without any peculiar symptoms. At the autopsy, the body appeared moderately well nourished, and the skin remarkably pale. Both lids on the right side were sunken from removal of the eyeball.

On removal of the skull-cap, the dura mater appeared tightly stretched and thinned, so that the blood-vessels of the pia mater could be partially distinguished; in the superior longitudinal sinus was loosely coagulated blood. The inner surface of the dura mater was covered with a moderate amount of purulent exudation, which was chiefly accumulated next to the veins of the delicate pia mater, and which were filled with dark, stagnant blood, being especially abundant on the left side, as well as in the subarachnoidal space over the cerebellum. The brain was swollen, the convolutions flattened, the fissures obliterated, its substance soft, especially the cortical layer, which, in several places, adhered to the pia mater. The ventricles were enlarged and held turbid serum; the right corpus striatum was flattened, softened, and the appendima dotted with small punctated ecchymoses.

The under surface of both frontal lobes adhered to the dura mater. After breaking up the adhesions, during which operation an ichorous discharge flowed from the deeper structures, there was seen lying on the under surface of both frontal lobes (Fig. 7) a new growth (*a*), which covered the greater part of the cerebral cavity, reaching to within about 2 cm. of the anterior border of the frontal lobes, and which had a slightly convex surface—in some places smooth, in others finely porous or fissured; feeling in some places hard, in others fluctuating; being 5½ cm. long, and from 4–4½ cm. wide.

This growth was dirty-white, tinted in spots a reddish-yellow or pale-green, and contained here and there little extravasations of blood (*c*); it was so placed on the under surface of the optic commissure that the whole right optic nerve was concealed by it, and the greater portion of the commissure seemed to be covered by it to within 1 mm. of its posterior border; while the left optic nerve (*l o*) was pressed outwards and downwards, and lodged in an accompanying furrow in the left half of the tumor, where somewhat curved, and embracing in an arc some portions of the growth, it passed forwards.

The pseudoplasm was connected on the under surface with the pituitary body, which became broadened while lying in the widened sella turcica, whose back wall was so strongly retroflexed that it appeared horizontal, and continued in the opposite direction, through both optic foramina, into the orbital cavities, prevalently in the right one, the adipose tissue of which, as well as the muscles, were infiltrated with an ichorous fluid.

A section through the pseudoplasm shows the anterior portion of the growth softened by a species of ichorous decay, extending to the contiguous surface of the brain-substance (*d*), while the posterior half is tough for the depth of 5 mm. from the surface, but then likewise becomes softer, and shows one part of a whitish, another of a yellowish hue, the latter especially appearing in the softer central portion, on the border of which are distinctly seen vessels gorged with blood or small hemorrhages. On each side, outwards from the corpus striatum, is seen a centre of softening larger than a penny, which, on the left side, is yellow, and filled with numerous small capillary apoplexies; but on the right appears whitish and surrounded by small extravasations.

In the remaining organs, there was nothing abnormal. The microscopic examination of the brain-tumor (Fig. 8) shows that it consists of stellate cells, with long anastomosing offsets (analogously to the tumor removed from the right orbit) which in some places form a network, in others are placed so thick upon each other as to produce the impression of a fibrous tissue filled with cells. Next to the hemorrhagic spots, as well as in the softened portions of the tumor, are to be seen vessels widened and frequently anastomosing (Fig. 9), some of which are filled with blood (*a*), some covered with extravasations (*b*), and others present a proliferation of cells in their sheaths (*c*).

The position of the removed tumor immediately upon the optic nerve, its intimate union with the nerve, its white color corresponding to nerve-marrow, made the supposition seem justifiable that in the preceding case we had perhaps to deal with a neuroma of the optic nerve, which, in considering the known cases, is in any event to be noted as rare; for in spite of the great experience of Rokitansky* and Virchow,† neither of them has ever seen a true neuroma of the optic nerve; the case published by Perls‡ being the only true neuroma on record. In that case there was also present a retrobulbar, egg-shaped orbital tumor, lying close to the globe which, surrounded by the sheath of the optic nerve, gave upon section a softer peripheric, brownish-yellow mass, and a tougher one which corresponded to the course of the optic nerve, and which was pervaded by opaque spots and delicate lines.

By the microscopic examination were recognized nerve-fibres both with and without medulla, as well as cells of divers shapes, nearly all of which ran into one or more nerve-fibres. In spite of a careful examination, a like condition could not, as before stated, be found in the tumor previously removed, and therefore the conclusion of its being a genuine neuroma had to be excluded from the want of distinctly recognizable nerve-fibres; so much the more so as the subsequent discoveries of the autopsy gave cause for another conclusion.

By the autopsy, the case I have communicated gains a striking resemblance to the one published by v. Gräfe,§ in which the orbital tumor of a six-year-old child springing from the optic nerve, and completely enveloping it, appeared entirely circumscribed, but at the autopsy of the child, who died of purulent meningitis eight days after the operation, a slightly nodular, grayish-red, partly translucent tumor lying over the pituitary body, and reaching to the crista Galli, was found, which produced a strong retroflexion and acute inclination of the sella turcica, as well as compression of the pituitary body, and in which the optic commissure as well as parts of both optic nerves had been absorbed.

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* Rokitansky: Manual of Path. Anat., 1856, Vol. II., page 501.

† Virchow: Morbid Growths, Vol. III., part I., page 298.

‡ v. Gräfe's Archives of Ophthalmol., Vol. XIX., part 2.

§ Gräfe: Arch. of Ophthalmol., Vol. XII., 2, page 100.

Microscopic examination showed the presence of pus-cells, round cells, and also a great number of fibre and net-cells with remarkably long filamentous processes, and upon these grounds, by reason of its composition being analogous to the neuroglia tissue, the diagnosis of glio-sarcoma was arrived at. If the aforementioned result of the microscopic examination of the orbital tumor as well as of the brain tumor be compared with the histological results taught by the case of v. Gräfe, the similarity of the two cases can be the more readily acknowledged as, according to Virchow,* cells of the most varied form—round, spindle-shaped, star-shaped with long processes, etc., belong to glioma, while the nerve-elements in the normal neuroglia entirely disappear. If then, according to Virchow, we have to assume that those tumors had developed by excessive proliferation of the neuroglia elements alone, the fact stated by Klebs † in his "Contribution to the Doctrine of Tumors" shows to the contrary that in those tumors of the central nervous apparatus, designated as glioma, the nervous elements, fibres as well as ganglionic cells, assist, not passively but actively, in the formation of the tumor, so that the structure is not the same in all phases of its development; for the new growth may consist in the beginning of a small-celled proliferation, and at the later stage many-branched cells may preponderate. It would be of importance to further investigate this question, especially as Klebs communicates in article No.

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* Virchow: Morbid Growths, Vol. II.

† Klebs: Prager Quarterly Journal, 34, 1877.

13 (l. c.), a case of neuro-glioma of the optic nerve, in which the right optic nerve, having a thickness of the little finger, was changed into a soft encephaloid mass, which on one side passed without a definite outline into the optic commissure, expanded on the other in the direction of the orbit, and formed round prominences which filled the posterior portion of the orbital cavity. From the crossing of the optic nerves, the pseudoplasm forced its way into the lateral ventricles. As a result of the microscopic examination is mentioned "many-branched elements, resembling ganglion cells, besides very many cells either perfectly round or with slightly developed processes." With regard to the brain-tumor referred to in our case, is one equally noteworthy communicated by Klebs (l. c.), a cerebral neuro-glioma, which, by reason of its situation (as shown in Fig. 1), presents some resemblance to our case; for the new growth, which is covered with pia mater, stretches forward from the neighborhood of the corpus albicantia between the two olfactory nerves as a smooth, whitish, somewhat elevated mass, forming behind the optic commissure a slight elevation and coalesces with the left optic tract, while the infundibulum is absorbed by the tumor. By the microscopic examination there is seen in a section through the pia mater and the cortex in both parts, a tissue filled with numerous cells, and very many enlarged blood-vessels, spindle-shaped cells rich in plasma on the capillary vessels, as well as enlargement of the lymph spaces.

Klebs described the formation of cell groups by the process of division in the ganglionic cells, as the origin of the cell formation which was especially abundant in the nodular elevation of the cortical layer. According to Klebs, the gliomatous portion proceeds from nerve elements; he therefore designates as neuro-glioma the tumors usually called glioma. Hence it required a fresh and more extended examination to decide whether the preceding tumor should be classed as a neuro-glioma or not.

A longitudinal section through the cerebral tumor shows that the gyrus rectus of both frontal lobes is replaced by the new growth, while the convolution bordering on it, as well as the anterior portion of the gyrus fornicatus, is compressed.

The pia mater enveloping the new growth is considerably thickened, and the adjoining tissue, which gives the impression of brain substance, appears here and there, in a specimen hardened in Müller's fluid, of a dark olive-green color to the extent of 4 mm., while the medullary border lying underneath, or in places encroaching upon it, shows a more decidedly yellow tint, and is simply softer or shows in many places numerous curved fissures, which run, as shown by the magnifying glass, in a corresponding direction to the unusually thickened vessels, until at length some parts of the tumor consist of nothing but a bundle of irregularly enlarged vessels, whereby a shaggy or warty appearance is produced. A section made parallel to the preceding one, including the pia mater and the underlying tissues, gave on microscopic examination (320 diam.) an irregular dilatation of the vessels of the pia mater, which were well filled with round cells, and bordering on this a network formed of more or less broad fibrous bands inclosing blood-vessels here and there; between which is inserted a delicate network of stellate, distinctly nucleated cells which entirely corresponds in its form to the connective tissue of the spinal medulla, and whose meshes are either empty or filled in many places with round cells resembling white blood-corpuscles, which possess a distinct nucleus and finely granulated protoplasm. This network follows mainly the course of the vessels which, as previously mentioned, show an irregular enlargement, and display in places a perceptible proliferation of perithelial cells, which in the adjacent preserved convolutions appear as the only condition of the blood-vessels worth mentioning. In other places, both bipolar and multipolar ganglion cells are arranged without any typical order, yet without any perceptible alteration being apparent. The paler and softer portion of the tissue contains mostly round cells, which are in a condition of turbid swelling or fatty metamorphosis.

In the adjacent normally appearing convolutions is to be seen, besides the proliferation of the perithelial cells, enlargement of the vessels and perivascular lymphatic spaces. From the communicated result of the examination, it follows that the growth found at the base of the brain is principally composed of connective tissue, and that it mainly originated in the pia mater and cerebral vessels; consequently the supposition of a gliosarcoma seems perfectly justifiable, and is further supported by the thickening of the interstitial connective tissue of the degenerated convolutions of the brain. Finally the question arises, which of the two tumors was first developed, the one found in the orbital cavity or the one lying on the under surface of the brain? I am inclined to believe, from the course of the disease,* that the neoplasm developed upon the right optic nerve, and gradually advanced to the optic commissure and the neighboring brain substance.

EXPLANATION OF THE PLATES.

FIG. 1. Natural size of the growth removed from the orbital cavity; (*a*) stump of the optic nerve; (*b*) the irregular anterior border of the connective tissue sheath.

FIG. 2. Perpendicular section through the removed growth; (*a*) peripheral, (*b*) central layer.

FIG. 3. Isolated cells of the orbital growth; (*a*) cells whose protoplasm contains fat molecules; (*b*) cell dividing; (*c*) cells with one—(*d*) with two—(*e*) with several processes.

FIG. 4. Cells obtained by maceration; (*a*) small round cells; (*b*) cells with short processes; (*c*) stellate cells; (*d*) spirally twisted tails; (*e*) remarkably smooth cells.

FIG. 5. Perpendicular section through the growth and optic nerve; (*a*) double border line; (*b*) large section representing a fine network (320 diam.).

FIG. 6. Transverse section of the stump of the optic nerve; (*a*) stratified corpuscles.

FIG. 7. Under surface of the brain (frontal lobes with the new growth

attached (*a*); (*c*) small spots of coagulated blood; (*ch*) optic commissure; (*l o*) left optic nerve; (*d*) focus of softened spots.

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* I held the opposite to be probable.—M.

FIG. 8. Microscopic appearance of the brain tumor.

FIG. 9. Conglomerated vessels from the brain tumor; (*a*) vessels filled with blood; (*b*) covered with extravasated blood; (*c*) cell proliferation in their walls.

B. *Syphilitic Periostitis with Gummy Growths in both Orbital Cavities, Producing Exophthalmus on the Right Side.*

On Sept. 8th, 1877, M. A., 5 years old, was brought to my eye clinic on account of the projection and swelling of the right eye, with the remark that the disease had begun about three weeks before. I am indebted to my friend Prof. Schnabel for the following notes concerning her history.

The child was extremely ill-nourished and very sensitive to every disturbance. The right eye protruded so very much that its cornea was situated 15 mm. farther forwards than that of the left. Both lids and the conjunctiva were greatly swollen; the lower half of the cornea wrinkled and covered with pus; the upper half, on the contrary, still transparent. Between the eyeball and the upper outer wall of the orbit was to be felt a hard, moderately elastic, immovable tumor. The left eye also projected more than usual, though its external appearance was otherwise normal; but the ophthalmoscope showed the traces of previous optic neuritis. It was quite probable that this eye could still see large objects, but it was impossible to ascertain this positively. The movements of the globe were free, and the presence of a tumor in the left orbit could not be directly distinguished. From the child's nose flowed at times a bloody, purulent discharge. The xerosis of the right cornea made slow progress, so that on October 2d it was transformed into a brown, dry scab, which was covered by a fold of the chemotic conjunctiva. About this time, a similar tumor was discovered in the orbit, inwards and above, as also outwards and above; and a tumor-like prominence arose on the forehead over the nasal eminence. At the same time, the child complained of great pain in the teeth of the left lower jaw. The gums around them were greatly swollen and extremely sensitive to the slightest touch.

On October 21st, a tumor was likewise discovered under the left orbital rim.

On November 13th, a considerable quantity of ichorous fluid was discharged from the right orbit, after which the swelling diminished considerably. From that time on, the ichorous discharge was very abundant, but repeated microscopic examinations showed only pus elements.

At first, the possibility of a rapidly growing tumor, springing from the base of the cranium and speedily advancing from the cranial cavity into the orbital and nasal cavities, suggested itself; but this supposition was immediately dispelled, in consequence of the appearance of the swelling on the forehead, as also by the result of the microscopic examination of the discharge from the orbital cavity, and the diagnosis of a uniform inflammation of the soft parts in both orbital cavities, dependent upon constitutional causes, was substituted.

On November 26th, an autopsy was held on the anæmic and emaciated body of the child, and gave substantially the following results:

Over the nasal prominence, a moderately hard-feeling, flat tumor, covered with normal skin. The right eyelids swollen, the conjunctiva so much so that on one side it appeared upon the cornea like a wall; on the other, under the outer eyelashes, it formed a decided prominence pressing the lower lid down, next to which, pointing in the direction of the inner eyelashes, is found a loss of substance 1½ cm. long, 7 mm. wide, but shallow, whose surrounding parts are discolored, which discoloration extends partly upon the swollen right cheek. The tension of the globe, which projects and separates the lids, is moderately hard, and the cornea is dry. After dissecting the scalp from the skull, it becomes apparent that the flat tumor lying over the nasal eminence is attached through a fatty, hard, grayish-yellow new growth, springing from the periosteum and adhering pretty closely to the bone, about 1 cm. thick and diminishing in size towards its periphery, which, following the bone, beginning from the middle of the right upper orbital rim (which is thickened and shows a bony protuberance curving outwards and upwards), nearly to the outer end of the left upper orbital rim, expanding upwards in the shape of a half-moon, its expansion covered with a spongy, large or fine granular layer of osteophyte for 4 cm., which disappears on its upper border in a thin periosteum, comparable to a ring-like growth penetrated by enlarged sinuses, but on its lower border at the base of the nose it is rather sharply defined.

Still other similar smaller, but moderate thickenings of the periosteum appear over the nasal eminence and also on the frontal bone, especially on the right side next to the coronal sutures; furthermore, on both parietal bones next to the sagittal sutures which, following the sinuses of the external bony plate, appear remarkably widened and deepened, and from there out, are seen many shallow furrows, often long branched, coursing over the bony surface, so that here and there the furrowed spots remind one in their appearance of bony corpuscles.

The removed skull cap, which is 3 mm. thick and compact, appears unsymmetrical in the course of ossification of the left lower half of the coronal suture, as its left frontal half is shortened; the right parietal bone, on the contrary, is expanded. The inner table of the skull, along the sagittal suture as well as in the region of the parietal eminence, is covered with a very thin but still recognizable layer of osteophyte.

The dura mater, which is tightly stretched, occasionally shows in the cerebral cavity, on both sides of the superior longitudinal sinus (which holds a considerable quantity of coagulated blood), a quite noticeable hard thickening, about 4 cm. long, whose cut surface appears homogeneous. The pia mater as well as the brain contain but little blood and are œdematous.

The right globe, when removed from the orbit, shows a mass lying upon its upper half, uniformly hard, 1½ cm. thick, appearing homogeneous on its cut surface; to the inner half of which the superior rectus as well as a portion of the superior oblique is attached, and which extends the whole length of the orbital cavity. It is loosely united by spongy connective tissue with the upper surface of the eyeball, and posteriorly conceals the optic nerve, whose sheath appears thickened. The lower half of the globe is surrounded by adipose tissue as usual, and on its inner half the remaining muscles of the eye are to be found. The periosteum of the right orbit is thickened, especially at its upper and outer rim; at the latter point it is connected with the previously mentioned new growth; the lower orbital wall is decidedly ichorous. After removal of the periosteum, the bone of the upper as well as the outer orbital wall appears rough and porous. In the left orbit is a similar hard fatty mass which likewise surrounds the superior rectus, although it is connected with the globe by a slight expansion.

The soft parts of the right cheek are in places infiltrated with ichorous fluid; the outer surface of the large right wing of the sphenoid as also that of the left temporal eminence is rough and porous. The periosteum of the lower jaw surrounding the back teeth is thickened, as well as that covering the coronoid process, and a new osseous formation has enlarged the underlying bone. Isolated glands in the neck are somewhat enlarged, one of them showing caseous degeneration in the centre. Otherwise no noteworthy pathological changes in the remaining organs.

The microscopic examination of the thickened portion of the periosteum, as well as of the hard fatty mass found in both orbital cavities and also of the thickened dura mater, gave the same result. A rich luxuriant growth of round nucleated cells, about the size of white blood-corpuscles, lies in a fibrous connective tissue, whose protoplasm is here and there in a state of fatty decay. A section through the middle of the hardened right globe shows its upper as well as its lower portion, especially the former, and occasionally its middle portion, pressed inwards by the adjacent new growth, by reason of which its section presents the form of a biscuit. The anterior chamber of the eye appears diminished in size, the lens smaller and strongly pressed against the posterior surface of the iris; the posterior portion of the vitreous humor transformed into a dirty white glue, which in places resembles a fibrous mass, while its anterior portion is more transparent. The papilla is 2 cm. thickened, and the sheath of the optic nerve is widened.

Microscopic examination of the right eye showed on the swollen conjunctiva a hypertrophy of the papilla which was abundantly covered with epithelium and contained enlarged vessels; also a band of submucous connective tissue filled with round cells. The cloudy portion of the vitreous consisted of a delicate network of connective tissue, in which were lodged round or more frequently small cells furnished with many rather long offsets projecting everywhere from their periphery; the former being mostly found in the transparent, the latter in the cloudy gluey portion of the vitreous. The swollen papilla of the optic nerve showed an enlargement of the nerve-fibre layer, which was permeated by many round cells, especially in the vicinity of the vessels; which also showed a swelling of the retinal layers, especially that of the ganglionic cells; and furthermore an accumulation of cells in the choroid. A similar accumulation could be distinguished in the interstitial connective tissue of the optic nerve. The papilla of the left eye also appeared swollen, yet was devoid of cell growth. If all the results obtained from examination of the body and the diseased organs be taken together, it is evident that the very rare occurrence is presented of a syphilitic periostitis of the skull of a child five years old, with gummy nodes developed in both orbital cavities; which latter led to exophthalmus on the right side, and finally to inflammatory productions in both eyes.

GLAUCOMA APHORISMS.

By L. MAUTHNER.

Translated by JAMES A. SPALDING, M.D., Portland, Maine.

A. THE OPERATION FOR GLAUCOMA.

I. *Iridectomy.*

SUPPLEMENTARY to a paper "On Iridectomy and Sclerotomy in Glaucoma," which I published last year in the Wiener Med. Wochenschrift (Nos. 27–30, 1877), and excited thereto by the late publication in Graefe's Archiv (XXIV., I., 161, 1878) of a paper by Hirschberg, "On the Prognosis of the Operation for Glaucoma," I here beg leave to discuss once more and somewhat more deeply the question of the operation for glaucoma.

In so far as I am personally concerned, the question has a peculiar interest for me, because my honored colleague, Hirschberg, at a debate on the glaucoma question in the Berlin Medical Society (Nov. 21st, 1877), and lately in the paper just cited, quotes from my paper a sentence without giving its connection, which contains the question: "As to whether it is allowable to subject an individual, still capable of work, to an operation (iridectomy) which may lead so quickly to the destruction of sight." Now, to speak with Hirschberg: "As twenty years have elapsed since von Graefe's beneficial discovery," and everybody knows that glaucoma is curable by iridectomy, my question may at first sight appear startling; nay, even paradoxical, heretical, absurd. But leaving out of consideration the fact that its meaning does become clear from the context, I am willing to believe that, even without the context, it has grounds, possibly sophistical, for justification. For as, on the one hand, such eyes as are affected with acute inflammatory glaucoma, or with extensive cloudiness of the media after chronic inflammatory glaucoma, and on the other hand, eyes which are blind from absolute glaucoma, are *not* capable of work, then it follows that I do not object to the applicability of iridectomy in inflammatory and absolute glaucoma; nay, but in this respect I go even further than Hirschberg, who cannot make up his mind for iridectomy in a case of inflammatory glaucoma absolutum, on account of the danger to the other eye (l. c., 184). We have left, therefore, those cases of glaucoma simplex and glaucoma chronicum inflammatorium, in which the patients are *still* capable of work, although the central or peripheral vision, or both, have suffered severely from the disease of the optic nerve. Now these are the cases that my question touches, and I will answer it by giving it a direct denial.

I put my own question; I answer it, and negatively, from my experience; for one's own experience is the only criterion as to the success of an operation. Of what good is it to me, if v. Graefe and "the best observers" cure ninety per cent of glaucoma simplex by iridectomy, and *know nothing whatever* of those bad results, for which in certain cases I reject the operation entirely; of what good is it to me, if, after perfect recovery from the *operation*, these bad results have fallen to my lot? It is all very well to fall under the constraint of reverence for the authorities in science (not by any means the weakest in our branch), in so far as theory is concerned, but it is going too far to allow it an influence in practice. All the belief in all the authorities can never help me to restore sight to those from whom, by an iridectomy, I have cut off a life of ability to work, nor to those whom I have seen undergo the same fate after the operation by the most skilful hands.

I reject iridectomy for certain cases of glaucoma, and so much the more decidedly as, up to this time, I have not seen such bad results after sclerotomy. We know not how iridectomy may be of so much help, nor how it may be of so much harm. How then could we declare that in certain cases it was not the excision of the large piece of the iris that did the harm, so that when we perform sclerotomy the dangerous element is removed, and only the good one remains? I appeal to the *authority* of v. Graefe, who, in cases of extremely contracted visual field (only, however, in glaucoma simplex of *myopic* eyes), saw the central vision suffer extensively after iridectomy. He can only explain this to himself, at least in his last paper, "*by some harmful step in the operative interference.*" It is plain from this, that V. GRAEFE had hardly made up his mind, that, because this harmful action resulted from the scleral wound and excision of a piece of the iris, it must be due *to the scleral wound alone.* It is here that I oppose Schweigger, who, in his terse paper on glaucoma (Volkmann's Vorträge, No. 124, 1877), says of sclerotomy: "We send sclerotomy off on its travels with a rather doubtful recommendation, by placing it superior to iridectomy, simply because the latter sometimes surprises us very disagreeably." For "if we regard the curative action of the operation as independent of the excision of a bit of the iris, we might then equally as well ascribe the harmful action to the incision simply, and not to the iridectomy." Yes, to be sure, so long as we are discussing *theoretically* the active principle in the operation for glaucoma. But when we can offer proof that, *in point of fact*, the curative action of iridectomy is due to the sclerotomy, then it is for its opponents to bring this contrary proof: that, *in point of fact*, the same bad results are met with as after iridectomy. It is worth noticing here that Hirschberg, basing himself on an observation made in fact after sclerotomy (in a province, however, far outlying our material for discussion), supported Schweigger's views, although, as I think, he ought to have reached an exactly opposite conclusion. Now Hirschberg performed iridectomy ten times for acute inflammatory glaucoma, and saw acute glaucoma break out twice in the other eye, on the second day after the operation; while after one sclerotomy he saw "pericorneal injection, increase in hardness, and arterial pulsation," break out in the second eye, *but pass away spontaneously.* But now, if I had seen that terrible disease, acute glaucoma, break out in the second eye after an iridectomy, while after sclerotomy transitory symptoms only (and those not endangering the eye in the least) became visible, for my part, if I at all regarded the operation as an especial cause of the affection of the other eye, I should not conclude that sclerotomy and iridectomy had similar sequences; but, on the contrary, I should point out that the traumatic influence was quite unimportant in sclerotomy, while in iridectomy it might cause the most grievous results to the second eye, and also that, if such bad results were frequent, all other things being equal, sclerotomy should be unreservedly preferred to iridectomy. If Hirschberg declines to employ iridectomy in absolute inflammatory glaucoma, because he fears acute glaucoma in the other eye, then he ought, according to his own experience, to try sclerotomy, which neither he nor any one else has ever seen followed by similar results.

When I come forward as a supporter of sclerotomy, my position is easily tenable, for in so doing I do not defend any theory. I understand the action of iridectomy just as little as that of sclerotomy. I know just as little of the cause of glaucoma as of the foundation for its operative cure, and if any one were to recommend to me to-day any new operation as—*cum grano salis* —a cure for glaucoma, I should not doubt as to the *possibility* of the affair.

Claude Bernard said in his last lecture, shortly before his death: "Most errors arise from the tendency to look upon a hypothesis once uttered as a proposition, for whose defence one *must* furnish arguments, just as if it were a criminal trial, which *must* be won by pleading." I do not need sclerotomy to support any hypothesis, I cling simply, as Schweigger says: "to the coarse but healthy fare of simple facts."

Now then, to go to work systematically, we are forced to say that the *direct* ill results of iridectomy (I speak of ill results after a *normal* operation and *normal healing*) are to be brought under three headings :

1st. The operation *per se* is *innocent* as to the ill results, which are due to some abnormal modifications of the mysterious processes of the disease called glaucoma.

2d. The operation is at fault *on optical grounds*, because indistinct images only can be formed on the retina, owing to the abnormal curvature of the cornea, but especially to the coloboma.

3d. In the operation as such, we must seek for some cause of the rapid decline of vision in *an unfavorable influence upon the disease of the nervous apparatus.*

Under class 1, we have to reckon first of all those cases in which iridectomy, in the common type of acute glaucoma (not fulminating, and still less hemorrhagic glaucoma), has not succeeded in restoring and preserving vision, although it has done its part in removing the inflammatory symptoms and diminishing the tension of the globe.

Madame D., æt. 66, Sept. 26th, 1871, has always seen well both far and near, and has worn glasses for ten years for reading and writing. March 5th, 1871, she had an attack of dysentery; March 18th, when she left her bed for the first time, she had in the evening an attack of very violent pains in the right side of the head, with redness and swelling of the eye, and when morning broke, she noticed that the sight of this R. E. had diminished to mere perception of light. After thirty-six hours, the pains lessened, without, however, wholly disappearing, and the eye became less swollen. Iridectomy was performed at Bozen on the tenth day after the attack, and during the operation the lens was wounded. The pains decreased at once, but there were repeated relapses, and in July, 1871, a new attack of unusually severe pain destroyed the sight completely. Pain constant in R. E., but L. remained wholly normal. Sept. 16th, 1872, the patient consented to an enucleation of this right eye.

Four days later, at evening, L. E. was attacked in the same way as the other had before been, and after a night of terrible pain, vision of this eye had sunk to mere perception of light. Sept. 26th, an iridectomy was made downwards, after the following state of things had been confirmed. Lids moderately swollen; conjunctiva of globe dark-red; cornea normal; iris discolored; pupil motionless, enlarged irregularly, cloudy; anterior chamber almost abolished; T. much increased; quantitative perception of light.

The wound healed normally. Sept. 29th, fingers at 3′. Three weeks later, patient was discharged with S. $=\frac{10}{70}$; the field of vision narrowed in every direction, but especially inward. From the centre of the *blind* *spot*, the field of vision at 0* extends to 26°, 20 : 27°, 40 : 17°, 60 : 20°, 80 : 21°, 90 : 25°, 100 : 25°, 120 : 32°, 140 : 30°, 160 : 40°, 180 : 40°, 200 : 45°, 220 : 50°, 240: 60°, 260 : 59°, 270 : 59°, 280 : 48°, 300 : 37°, 320 : 40°, 340 : 35°. Mirror shows media clear, *no* hemorrhages in fundus oculi ; papilla not excavated, but its borders somewhat indistinct.

This result, three weeks after iridectomy in a simple case of acute glaucoma, and six days after its outbreak, must be regarded as very moderate, and especially so as there were no retinal hemorrhages. But we shall be told by other observers that an improvement was to be expected in the following weeks.

But, instead of an improvement, after S. had remained about the same for six weeks, vision decreased gradually without pain, so that Feb. 20th, 1873, *fingers* could only be counted at 1½′, and the field of vision was much contracted. T. not distinctly increased, and yet pressure causes arterial pulsation. Eye pale, externally normal, media clear, optic nerve pale, no trace of excavation ; *small yellowish spots, both right and left of optic nerve.*

After medical treatment (two injections of strychnia, then calomel, later quinia and zinc), fingers counted March 19th, at 6′. Finally, a second iridectomy upwards and directly opposite the first : no alteration, T. unchanged.

Up to Oct., 1877, patient has not become blind ; on the contrary, she sends word that her sight has improved somewhat.

The cause of this unfavorable course is not clear. The numerous yellowish spots (evidently due to an alteration in the pigment epithelium) have a peculiar meaning when we recall analogous discoveries by Graefe† and Hirschberg,‡ both in cases of glaucoma simplex, running an abnormal course. Iridectomy is not to blame for the result ; that is to say, no one will affirm earnestly that it would have been better for the patient had an iridectomy *not* been done.

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* 0, 20, 40, etc., to 340 denote the meridians of the field of vision, where 0 stands at the upper end of the vertical meridian ; the spokes counting from left to right.

† Archiv, XV., 3, 234, 1869.

‡ Archiv, XXIV., 1, 189, 1878.

In this same class we might include those cases of glaucoma simplex in which indeed vision sinks after iridectomy, but where the peculiarity of the morbid process is shown by a lack of coincidence of the objective and subjective results; *i. e.*, in spite of precisely similar iridectomies in both eyes, we find *lower* S. in the eye in which, from the objective state, we should have expected to find it *higher*.

Now, if in the *second* class (where S. becomes *extremely* bad owing to a coloboma, even when made upward) we comprise all cases, then, let any one oppose it who may, there would be no end to the list. This deterioration is not so startling when the patient sees so poorly before the operation that there is but little question as to a plus or minus of sight; but it is indeed startling when a considerable amount of sight is still present at the time of the operation. We learn much on this point from patients who have been operated upon by *other surgeons*, because they are usually courteous enough to the present operator to say that they do not mind "this bit of poorer sight," so that when they consult a second surgeon, they can let loose all the more energetically against both operator and operation. For a long time I had been in the habit of telling every patient with glaucoma without cloudiness of the media, that the operation (iridectomy) would in all probability diminish the sight, and that I only undertook it so as to keep for him this supplementary vision, impaired though it might be. I cannot see how any one can appeal to the harmlessness of coloboma after a cataract operation, for any man blind with *cataract*, and who has his vision restored, has to be content in the end with such acuteness of vision as has been gained, although without a coloboma he would surely have had a higher acuteness; while to a glaucomatous patient who can see, the decrease becomes perceptible after the operation. This effect of a coloboma is proved in that the sight of patients who have had iridectomy made, increases in many cases when we make them look through a small hole in a diaphragm.*

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* Compare Schnabel, present number of these ARCHIVES.

The optical disadvantages of a coloboma are very glaring under some circumstances; for instance, when regular or irregular astigmatism were *previously* present, or where the curvature of the cornea was harmed by an imperfect operation, iris incarcerated in the wound. Then it is that we find *diminution* of sight, even to total uselessness, *beautifully colored* borders around objects, and even *polyopia*. I have communicated a case (l. c.) where an astigmatic patient with glaucoma simplex, and who before the operation (iridectomy inward) could read J. 3, could, after the operation, read only J. 16; and another rare case where a patient, æt. 22, with myopic astigmatism after an upward iridectomy for glaucoma simplex, saw everything double and edged with colors, which differed from the colored rings which the patient had before seen, now and then after his glaucomatous attack, in that they were always present, being due to the uncovering of the extremely unsymmetrical periphery of the astigmatic optical system.

Here is a striking case of polyopia, caused by an imperfect iridectomy.

Joseph Emberger, æt. 57, July 13th, 1870, lost all vision in L. E. three years ago, after a terrible inflammation of the eyes which lasted nineteen weeks. L. E., glaucoma absolutum. Soon after this loss of sight, R. E. was attacked. He saw rainbows whenever he looked at the light, and noticed that his sight was bad. Iridectomy upward at Munich. The *rainbows disappeared* after the operation, but he could see several flames instead of one, and as he said with great emphasis, "one hundred and fifty flames," as also all objects double. Lately, the colors have returned, and he seeks help.

S. $\frac{10}{100}$, J. 8 with difficulty at 7″, F. (1′ distant), upwards 11″, downward 11″, outward 8½″, inward 13″. Large shreds of iris have healed in the wound, and there is irregular astigmatism in a high degree. T. normal, no excavation. To correct the iridectomy, a bit of the iris (outwardly) was excised. March 13th, 1877 (7 years later), Emberger says that his sight is the same, but he complains of the glare, and the "many lights instead of one light."

In this second class, therapeutics have a weighty problem to solve. Where cylinders, or cylinders alone, do not remedy the evil caused by the coloboma, we may resort to tattooing of the transparent cornea from its edge towards the centre ; this was done in the previous case, and the tattooing of the cornea 2 mm. in breadth at the edge of the coloboma removed the colored vision. Our indications for tattooing are, when we find the vision decidedly improved on placing before the eye a diaphragm with an opening of a few mm. in diameter. We may also have recourse to tattooing where iridectomy has not really lessened the vision, but where, even with an *upward* coloboma, the operation has produced a dazzling which is very harmful to one's occupation—see the case of the Vienna cab driver, l. c.

In the third class, we find that iridectomy brings on a rapid decline in the functions of the retina.

Hirschberg is right in laying great stress on the statistics of the operation for glaucoma. Hence, I will add a small contribution thereto.

As will be seen from my communication on this point in the Heidelberg Ophthalmological Society in 1869, I had then already seen several cases where vision had decreased rapidly after iridectomy. In order to illustrate this point still further, I beg leave here to offer some statistics of cases of primary glaucoma without cloudiness of the media, which I submitted to iridectomy during my residence at Innsbruck. The presence of cloudiness of the media in cases 3 and 9, does not turn the balance in favor of iridectomy.

CASE I.—Johann Lengauer, æt. 72, July 8th, 1870, noticed a blur before his sight two years ago, and a year ago, that he saw worse with his right eye than with his left. The amblyopia increased, until he noticed, one day, that his right eye was quite blind. He comes now for help, because, since New Year's day, he has been unable to see the "lines and strokes" at his cabinet-making with his left eye.

Glaucoma simplex both eyes. R., amaurosis : L., S. $=\frac{10}{70}$; with $\frac{1}{30}$, S. $=\frac{10}{40}$; with $\frac{1}{8}$ J. 4 at 8″. July 13th, L., iridectomy upward. July 25th, some blood in the anterior chamber. S. $=\frac{10}{200}$; with $\frac{1}{8}$ J. 13 at 5″. August 18th, some blood still remains in the anterior chamber. S. can be brought to $\frac{10}{50}$, but he reads with $\frac{1}{8}$ *only* J. 9, *and at* 7″.

CASE II.—Johann Werlberger, æt. 55, August 1st, 1870. For two years he has seen nothing with R. eye, and, since last winter, but poorly with L. Glaucoma simplex both eyes. R., no perception of light. L., S. $\frac{10}{70}$; with $\frac{1}{16}$ J. 15 at 10″. F. (distance 1′), upward 8″, downward 0, outward 15″, inward 4″. August 2d, iridectomy upward L. E. August 27th, artificial pupil correctly made. S. $=\frac{10}{200}$, with $\frac{1}{16}$ spells J. 17.

Seven years later, March 12th, 1877, patient answers our inquiries:

"When I was in the clinique, the doctor led me into a room where the A B C was. Then I could not help thinking that my sight was gone." (This explains additionally the great difference between the acuteness of vision for near and distant objects.) "Since then it has grown worse. People tell me that the pupil is too large. Looking straight ahead, I see nothing downwards, not even the tips of my shoes." (This total defect in the field of vision existed seven years before.) "It seems to me as if I were all 'overlighted;'" but as we draw from the whole account, 'overlighted' Werlberger is not yet quite blind.

CASE III.—Anna Muhr, æt. 61, May 4th, 1871, noticed nine months ago that she saw poorly with both eyes. R. E. grown rapidly worse within three weeks.

R., T. increased, aqueous cloudy, optic nerve excavated. S. $=\frac{10}{70}$; with $\frac{1}{16}$ spells J. 8 at 10″.

L., T. increased, optic nerve excavated, and of a dark-green tinge, quantitative perception of light. May 6th, iridectomy in both eyes, upwards. May 11th, R. fingers at 6′. May 17th, at 8′. May 27th, T. lessened in both eyes, iridectomies made correctly in both eyes, but R. E., which, in spite of cloudiness of the media, had S. $=\frac{10}{70}$, *can only count fingers at* 8′. L. E., quantitative perception of light.

CASE IV.—Stefan Mairamhof, æt. 34, October 25th, 1871, had, at the age of 12, an inflammation R. E., which lasted for two winters. Four years ago, this eye was inflamed again, very painful, and after a night there was no sight remaining. Last March, a violent inflammation L. E.; the patient noticed that the pupil dilated and that the whole eye grew larger. Four days later, the eye seemed of usual size, inflammatory symptoms disappeared, but vision was impaired.

R. E., T. +3 (40 with Monnik's tonometer), central cloudiness of cornea, and at the edge a bluish ectatic spot of sclerotica. Posterior synechiæ, total excavation of optic nerve, quantitative perception of light.

L. E., T. +3 (40 Monnik), bluish border around cornea, posterior synechiæ, reads J. 17 hesitatingly at 8″. F., upward 40°, downward 25°, outward 65°, inward 20°.

October 28th, iridectomy in both eyes, upward. November 2d, L. E., anterior chamber restored. A nine-pin shaped *anterior* synechia has developed itself downward; cloudiness where the iris is applied to the cornea. Synechia not to be removed by energetic use of atropine.

November 8th, high degree of astigmatism in both eyes, and the papillæ look transversely oval in erect image.

November 17th, L., S. somewhat improved by $-\frac{1}{12}$ c., but patient stumbles over J. 21 at 8″. Pupils extremely dilated.

Reports from patient, March 13th, 1877, say that "he sees nothing at all, just as when he left the hospital." (This is false, that he left the hospital blind.)

Case V.(*) †—Josef Waltl, æt. 63, October 17th, 1871, began to lose sight L. E. four years ago; has seen nothing with L. for two years. Vision of R. E. has been decreasing for a year and a half.

L. E., T. +3, 43 Monnik, amaurosis, excavation, all else normal.

R. E., T. +3, 45 Monnik, S. $=\frac{10}{40}$; F. reaching only outwardly 20°. Excavation, nothing else abnormal.

October 19th, R., iridectomy upward.

October 30th, blood absorbed from the anterior chamber, media clear, S. only $\frac{5}{70}$.

November 21st, S. fallen from $\frac{5}{70}$ to $\frac{5}{200}$; or, *by the operation* S. *has decreased from* $\frac{10}{40}$ to $\frac{5}{200}$.

We learned in January, 1877, that patient's vision had "grown much worse." I cannot say whether this means that the patient is blind or not.

Case VI.(*)—Simon Mayrhofer, æt. 56, Jan. 10th, 1874; largely developed veins around the circumference of both cornæ. R. pupil dilated and motionless, L. pupil reacting but slowly; media clear. R., deep excavation; L., excavation distinctly beginning. T. + in both eyes. R., no perception of light; L., S. $\frac{10}{30}$, F. narrowed in all directions and almost abolished downward and inward. From the *centre of*

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† Cases marked with (*) have already been mentioned in the Wiener Med. Wochenschrift, l. c.

the blind spot (point of fixation 15° inward), F. reaches 15 at 0, then 12, 14, 18, 17, 17; 17 at 90, then 17, 18, 0, 0; 0 at 180, then 0, 0, 8, 26; 21 at 270, then 21, 21, 20, 14, 14.

Jan. 26th, L. E., iridectomy upward. Jan. 29th, puncture of blood in the anterior chamber. Feb. 20th, conjunctiva pale, iris beautifully excised, pupil black, T. increased, S. with weak concave glasses only $\frac{10}{200}$. March 2d, S. without glasses $\frac{10}{200}$; with $-\frac{1}{9}$ c. $\frac{10}{40}$.

Besides this, the operation had caused astigmatism, which was especially perceptible owing to the excision of the iris, and the eye which had had S. $\frac{10}{30}$ before the operation, had now S. only $\frac{10}{200}$, and even the best chosen cylinders did not raise vision to its former standard. March 16th, S., without glasses, $\frac{10}{200}$, but with the best cylinder (now $-\frac{1}{12}$), S. was only $\frac{10}{70}$, T. noticeably increased. March 18th, iridectomy downward. April 6th, fundus oculi clearly visible, no blood in the eye, papillæ pale-green, iris excised beautifully, the edge of the lens and the ciliary processes, upward and downward, beautifully distinct. T. diminished, but the man who at his admission had S. $\frac{1}{3}$, with his left and only eye, and who had been fully capable of work, counts now only fingers at 7′, and even with the most suitable cylinders, $-\frac{1}{10}$, S. increases only to $\frac{5}{70}$; *i. e.*, $\frac{10}{140}$ in comparison with $\frac{10}{30}$ before the operation.

Case VII.—Joseph Endleitner, æt. 65, March 28th, 1874, has had a steady decline of vision L. E. for five years, and for two years total blindness of the same. It was only after the eye became blind that violent pains were felt in and around it, with redness and flow of tears. For two years R. E. has been losing its sight, and quite noticeably within the last two months.

L. E., T. +2 to +3, ciliary veins extremely developed around the cornea; cornea not sensitive and very cloudy centrally. Vessels run from the edge of the cornea to this clouded spot; in its centre is a circular extravasation lying upon a blood-vessel. Some blood at the bottom of the anterior chamber, and between these two extravasations and uniting them is a stripe of blood 1 mm. in width. Lens opaque with radiating sector stripes very clearly delineated.

R. E., T. +2 to +3, ciliary veins around the cornea, which is less sensitive than L. Anterior chamber shallow, pupil not much enlarged and reacting slowly. Mirror shows the media clear, hypermetropia, total excavation of the optic nerve. S. $\frac{10}{40}$, O L; peripheral field of vision narrowed inward. From the point of fixation outward: 0 : 49, 49, 60, 65, 70; 90: 70, 70, 69, 60, 40; 180: 33, 10, 9, 17, 24; 270: 26, 26, 24, 50, 50.

March 31st, R. E., iridectomy upward. April 2d, wound not yet closed, no anterior chamber, pressure bandage. April 6th, a dark line in the wound, anterior chamber restored. April 10th, wound better united, bandage removed, perfect iridectomy.

April 20th, S. $\frac{10}{200}$; with $-\frac{1}{10}$ c., axis vertical, S. $\frac{10}{70}$. May 15th, S. $\frac{10}{200}$; with $-\frac{1}{12}$ c., axis vertical, S. $\frac{10}{50}$.

May 19th, as T. has not decreased, iridectomy downward, pressure bandage. May 20th, edges of wound applied, blood in the anterior chamber, injection somewhat excessive. May 24th, blood absorbed, anterior chamber very shallow, T. noticeably less.

June 10th, anterior chamber very shallow, T. subnormal, S. $\frac{10}{200}$; with $-\frac{1}{8}$ c., axis horizontal, S. $\frac{10}{100}$; a dark, floating membrane visible in the eye. June 12th, detachment of the retina, inward, distinctly visible.

July 7th, discharged.

In this case T. had not diminished after the first iridectomy, and on the other hand the *sight of the eye, without glasses, had fallen from* $> \frac{10}{40}$ to $\frac{10}{200}$; the second iridectomy caused *softening of the eyeball, with detachment of the retina*, and the anterior chamber was abolished.

Case VIII.—Jakob Kapeller, æt. 73, June 8th, 1875, has worn glasses for reading for twenty years. His left eye grew perfectly blind without his knowing anything about it, till he discovered it accidentally last Easter. Since Lent the sight of the right eye has decreased gradually. He has never had any pain or inflammation.

L. E., T. +2 to +3; a few ciliary veins about the cornea, which is wholly transparent and sensitive. The anterior chamber is not shallow, iris normal, pupil moderately dilated, round, *narrower than the right pupil*, and reacts promptly when the right eye is alternately covered and opened. Lens and vitreous transparent; deep total excavation; no perception of light.

R. E., same state, only the pupil is more dilated than left; it reacts to light and shadow. Excavation less deep; S. with $\frac{1}{50} = \frac{10}{50}$. Field of vision narrowed excessively in a slit shape.

May 21st, iridectomy upward, R. E. May 22d, anterior chamber very shallow, with some blood therein. May 24th, T. much lessened. May 25th, anterior chamber abolished. May 28th, anterior chamber restored, T. increased, S. $\frac{10}{70}$ with medium cylinders, no blood in anterior chamber. June 8th, anterior chamber restored, moderately deep, T. much increased, S. $\frac{10}{70}$.

July 29th, 1875, patient returned, on account of a renewed diminution of vision. T. +2 to +3; anterior chamber moderately deep, S. $\frac{10}{200}$, otherwise the appearances are as before.

Case IX.—Juliane Stiegelhofer, æt. 16, January 25th, 1870; had typhus and small-pox in childhood. At Christmas, 1868, she noticed a decrease in sight, which grew worse and worse; no family history of glaucoma.

R. E., T. noticeably increased; anterior ciliary arteries extremely prominent; sensitiveness of cornea somewhat lessened; pupil somewhat indistinct, on account of turbidity of aqueous, extremely dilated, but still movable. Vitreous clear; deep excavation of optic nerve; quantitative perception of light.

L. E., T. increased, but less than in R. E.; prominent ciliary arteries; cornea sensitive; media clear; pupil dilated, but reacting to light. Total excavation, and fingers counted uncertainly at 4″.

January 26th, iridectomy in both eyes, upward, with normal healing in L., and T. reduced to normal. R. E., January 27th, blood fills anterior chamber. January 30th, blood still present, extreme injection. February 1st, blood absorbed. February 2d, no anterior chamber, T. subnormal. February 5th, anterior chamber beginning to be restored at the periphery.

February 6th, with the restoration of the anterior chamber, we can recognize, downward, adhesion of the edge of the pupil to the posterior surface of the cornea in the form of a thin process; *i. e, a true anterior synechia.* February 7th, anterior chamber quite restored. T. normal; ciliary injection persists; blood-letting. February 9th, a slight haziness of the cornea where the iris is adherent; later, this comes out more distinctly. February 12th, prompt quantitative perception of light.

L. E., February 12th, counts fingers at 6″; F. (12″ distant) is abolished upward; downward it is 2″, outward $1\frac{1}{4}''$, inward $1\frac{1}{2}''$, inward and downward and outward and downward $1\frac{1}{2}''$. March 4th, fingers at $3\frac{1}{2}'$, J. 24 at 11″. Field: upward 0, downward $2\frac{1}{4}''$, outward 2″, inward 4″.

March 8th, as T. in R. E. had again increased gradually and constantly, a second iridectomy was made downward, and the synechia removed. March 9th, anterior chamber restored; March 11th, T. normal.

March 30th, T. in both eyes normal. R. E., quantitative perception of light. L. E., J. 22, F., upward 0, downward 8½″, outward 4½″, inward 4½″.

Seven years later, the eye has not grown blind, but, as patient reports, it remains *in statu quo*.

Case X.—Kunigunde Wergether, æt. 63, June 2d, 1870; has had weakness of sight L. E. since last winter, and pain in R. E. for the last six weeks.

L. E., with $\frac{1}{16}$, J. 17 at 10″ with some difficulty. Field at 12″ distance, upward 9½″, downward 18″, outward 17″, inward 5″. T. increased; the eye, externally, normal; media clear; pronounced curvature of vessels at the edge of the greenish papilla, and extensive arterial hemorrhages in the lower part of the fundus oculi.

R. E., S. $\frac{20}{40}$; with $\frac{1}{30}$, S. $\frac{20}{30}$, and perfect field of vision.

Treatment: potassium iodide, blood-letting at left temple; June 9th, iridectomy upward L. E., followed by hemorrhage into anterior chamber with pain and ciliary injection. Repeated blood-letting. July 14th, very slight ciliary injection upward and inward; no blood in anterior chamber; media perfectly clear; fundus oculi unaltered; patient *reads with difficulty words of* J. 17.

Case XI.—Josef Oerterer, æt. 55, June 14th, 1870; a stone hit his R. E. eighteen years ago while blasting rocks, and destroyed his sight. Ten years ago, his left eye was inflamed, his sight grew poor and has been decreasing ever since.

R. E., T. normal, globe somewhat smaller, ciliary injection. A bluish ectatic spot of sclera inward as large as a hempseed, and a second similar one outward and upward. Cornea, downward, of a milky hue; pupil contracted, circular adhesion to anterior capsule, and a pupillary membrane. No perception of light.

L. E., T. increased, cornea of a milky tinge downward, anterior chamber and iris normal. Total excavation of optic nerve. Eye turned inward in vision, and counts fingers at 6′. From the point of fixation as centre, F. reaches upward 7½″, downward 6½″, inward 4″, outward 6″. Iridectomy does not alter vision.

Case XII.—Elise Stoffner, æt. 59, April 22d, 1873; has seen threads and black bodies before R. E. for many years; vision has decreased, owing to a cloud before this eye, which has been growing thicker day by day for three years.

R. E., T. distinctly increased, ciliary veins around cornea ; cornea normal; iris not strikingly changed in structure ; pupil more dilated than in left eye, very sluggish in its reaction to light and shadows ; total excavation ; mere perception of light.

L. E., T. nothing abnormal except two pulsating veins in the retina. S. $\frac{20}{20}$. April 26th, R., iridectomy upward; April 28th, T. decidedly less ; May 13th, discharged with perception of light.

CASE XIII.—Alois Mayr, æt. 60, Dec. 2d, 1873 ; glaucoma simplex and *choroiditis exsudativa*. Patient has had several "*feverish*" diseases, had always seen well both far and near. Six years ago, he saw black spots and specks floating before his eye, and fiery flashes when in the dark. These appearances passed off under medical treatment, and his sight had not suffered at all. He had typhus fever four years ago, and since then his lower extremities have felt numb. At about the same time, both his eyes began to lose their sight, but they were never painful or reddened. A bit of iron hit his right eye three months ago, and caused an inflammation which ceased after a few weeks.

The eyes are very deeply seated; the upper orbital ridge being exceedingly prominent, measurements with the perimeter meet with the greatest difficulties.

T. much increased in both eyes, but especially in L. E. Nothing abnormal externally ; pupils irregular, from a few posterior synechiæ seen on lateral illumination. The corneæ are less sensitive than normally, a few sectors being anæsthetic. Mirror shows manifold floating and fixed opacities of vitreous. Slight myopia. Beautiful picture of total excavation, with overhanging edges in both papillæ. R. E., outward, downward, and upward-inward, complete atrophy of choroid, and the glittering yellowish-white sclera is plainly visible. A few strips of choroid, denuded of epithelium, still extend over these atrophic regions, and the vessels are very finely seen.

L. E., choroidal atrophy is even more extensive. Irregular heaps and smaller clumps of pigment are scattered over the whole fundus oculi.

R. E., without a glass, S. $\frac{10}{50}$; with $\frac{1}{36} = \frac{10}{30}$. L. E., fingers at 8′, S. $\frac{5}{200}$.

December 9th, iridectomy in both eyes, upward, with Graefe's knife. December 12th, blood in anterior chamber is absorbing slowly. December 20th, R. E., S. $\frac{10}{70}$; L. E., $\frac{5}{100}$. December 29th, R. E., S. $\frac{10}{100}$, and with $+\frac{1}{18}$ c., axis vert., S. $\frac{10}{40}$, and a few words of No. XXX.

December 30th, mirror shows the ciliary processes and edge of lens very finely. Very large extravasations in the retinæ, some sharply defined, some more diffuse; R. E. in the region of the yellow spot, L. E., especially inward from the papilla, also upward and downward. T. in both eyes almost normal.

March 13th, 1877, three years and three months later, patient writes that his eyes have been the same, “neither better nor worse.”

Case XIV.—Marie Kugler, æt. 65, March 25th, 1875; wept a great deal three years ago, and discovered one day before the left eye a fog, which soon destroyed vision. Since the autumn of 1874, R. E. has also grown much worse.

T. in both eyes +2, +3, pupils moderately dilated, that of R. E. reacting sluggishly, that of L. E. motionless to light. Deep excavation in both eyes. R. E., fingers at 8′; L. E., no perception of light.

March 27th, iridectomy in both eyes, upward. April 30th, both anterior chambers restored, the wounds well healed, T. almost normal; R. E., fingers at 10′, with weak concave glasses CC. at 10′.

In the following summary of twenty-three glaucomatous eyes, No. 15 is the case of Wagner, hereafter to be described; No. 16 has been mentioned previously as having the “colored borders” after the operation; Nos. 17 and 18 are to be found under the head of sclerotomy, cases Nos. 4 and 7.

No. 1.	Before	operation,	L., S. $\frac{1}{40}$; J. 4 at 8″.
	After	“	“ S. $\frac{10}{50}$; J. 9 at 7″.
No. 2.	Before	“	“ J. 15 at 10″.
	After	“	“ J. 17; worse seven years later.
No. 3.	Before	“	R., S. $\frac{10}{70}$; J. 8 at 10″; cloudiness of media.
	“	“	L., S. $\frac{1}{\infty}$.
	After	“	R., fingers at 8′.
	“	“	L., S. $\frac{1}{\infty}$.
No. 4.	Before	“	R., S. $\frac{1}{\infty}$.
	“	“	L., J. 17 at 8″.
	After	“	R., S. $\frac{1}{\infty}$.
	“	“	L., J. 21 at 8″; five and a half years later, S. =0.

No. 5.	Before operation,		R., S. $\frac{10}{40}$.
	After	"	" S. $\frac{10}{200}$; much worse five and a half years later.
No. 6.	Before	"	L., S. $\frac{10}{30}$.
	After	"	" fingers at 7′; with cylinders, S. $\frac{5}{70}$.
No. 7.	Before	"	R., S. $> \frac{10}{40}$.
	After 1st	"	" S. $\frac{10}{200}$; with cylinder, S. $\frac{10}{50}$.
	" 2d	"	" S. $\frac{10}{200}$; with cylinder, S. $\frac{10}{100}$. Retinal detachment.
No. 8.	Before	"	R., S. $\frac{10}{50}$.
	After	"	" S. $\frac{10}{70}$. Two months later, S. $\frac{10}{200}$.
No. 9.	Before	"	R., media cloudy. S. $\frac{1}{\infty}$.
	"	"	L., fingers at 4″.
	After	"	R., S. $\frac{1}{\infty}$.
	"	"	L., J. 22. Field of vision enlarged. Same state seven years later.
No. 10.	Before	"	L., J. 17.
	After	"	" J. 17.
No. 11.	Before	"	" fingers at 6′.
	After	"	" fingers at 6′.
No. 12.	Before	"	R., S. $\frac{1}{\infty}$.
	After	"	" S. $\frac{1}{\infty}$.
No. 13.	Before	"	R., S. $\frac{10}{50}$, with $\frac{1}{36} = \frac{10}{30}$.
	"	"	L., fingers at 8′. S. $\frac{5}{200}$.
	After	"	R., S. $\frac{10}{100}$; with $-\frac{1}{18}$c. S. $> \frac{10}{40}$.
	"	"	L., S. $\frac{5}{100}$. Three and a quarter years later, no change.
No. 14.	Before	"	R., fingers at 8′.
	"	"	L., S. $=0$.
	After	"	R., fingers at 10′.
	"	"	L., S. $=0$.
No. 15.	Before	"	L., S. $\frac{13}{20}$.
	After	"	" S. $\frac{20}{20}$ fully, a year later.
No. 16.	Before	"	L., S. $\frac{20}{20}$, almost.
	After	"	" S. $\frac{20}{20}$, almost.

No. 17. (Case 4, sclerotomy.)
Before operation, R., S. $\frac{20}{30}$.
After " " S. $\frac{20}{50}$; with cylinders, S. almost $\frac{20}{30}$. Two and a half years later, same state of vision.

No. 18. (Case 7, sclerotomy.)
Before operation, R., S. =0.
After " " S. =0.

Of these 23 eyes, 2 (Case 14 L., 18 R.) had S.=0; 4 (3 L., 4 R., 9 R., 12 R. [9 R. with cloudiness of media]) had S.=$\frac{1}{\infty}$. Iridectomy did not alter this condition. Of the 17 eyes with sight, 5 (10 L., 11 L., 13 R., 16 L., 17 R.) maintained the same vision, or with little change, but in 2 (13 R., 17 R.) *only by help of cylinders, and in* 1 (16 L.) *by tattooing;* in 13 R., S. (without glasses) sank from $\frac{10}{50}$ to $\frac{10}{100}$; in 17 R., from $\frac{20}{30}$ to $\frac{20}{50}$. In 3 cases (13 L., 14 R., 15 L.), S. was improved, but only remarkably in 15 L., where, after an iridectomy, the edge of the pupil was still intact. Of 17 eyes, 8 (1 L., 2 L., 3 R., 4 L., 5 R., 6 L., 7 R., 8 R.) had less vision after the operation, and in 5 of these 8 (3 R., 5 R., 6 L., 7 R., 8 R.) vision that allowed the patients to work was rendered useless, *and as in all* 5 *the patients had but that one eye, their ability to work was lost by the operation.* If we wish to make a flourish with percentages in such a small list, we may say that thirty per cent of the eyes were made useless by the operation.

Now since Hirschberg thinks that lamentations over loss of sight after iridectomy "are more often heard by those operators who make broad lateral artificial pupils, either inward or outward, in eyes attacked with glaucoma simplex, but having still some vision," let it here be said that, in all these cases cited, iridectomy was made *upward;* besides, let us not forget once more to point out the fact that even an upward iridectomy does not wholly prevent serious defects of vision, although these may be remedied in part by cylinders or by tattooing.

Diminution of vision after an iridectomy does not implicitly depend on the chances that the operation did not fulfil its task of decreasing the tension; *i. e.*, there is no strict connection between S. and T. In Case 8 only did T. remain high after the operation.

I believe now that I have, by these statistics of cases, given some support to my question, "As to whether it is really allowable to subject individuals, capable of work, to an operation which may so quickly ruin their vision;" and, moreover, I cannot forbear from remarking that complete recovery, by means of iridectomy in fresh cases of *acute* primary glaucoma, is not always to be taken for gospel truth. If the sight does not come up to our expectations after the operation, we think that possibly there might have been a former glaucomatous process in the eye, although an examination gives us no grounds for such a belief. The most instructive cases, in this respect, are those where glaucoma breaks out under the very eyes of the operator after an iridectomy in the other eye. I have, to be sure, seen such cases but rarely; but in the last that I saw, I had opportunity to confirm the fact that the eye which, before the outbreak of glaucoma, had S. $\frac{20}{20}$ almost, and a normal field of vision, and in which, three hours after the attack, iridectomy was made upward, had, sixteen days after the operation, and without any extravasations in the retina, S. only $\frac{10}{30}$, *i. e.*, hardly one-half of the central vision that it had before the attack, although the peripheral field of vision was intact. I cannot say whether a *decided* improvement followed, for the patient wrote a year later: "The eyes are the same, perhaps *somewhat* better than worse." This is not saying much; this permanent decrease in vision seems to be due mostly to the coloboma. The man ought not to complain, for, at the time of operation, he did not have S. $\frac{20}{20}$, but was almost blind; but when, even in forms of acute glaucoma, we substitute sclerotomy for iridectomy, we shall gain better results as to acuteness of vision.

The ill-results of iridectomy in glaucoma free from cloudiness of the media led me to try sclerotomy *empirically*. It is always a question of interest as to whether, in the long period of iridectomy, any chance experiments were made as to the action of the scleral incision. Up to the last, v. Graefe opposed the curative action of the *scleral* section, without, however, being cognizant of any explanation as to the benefit of the excision of the iris. Iridectomy is for him a purely empirical operation; but if—and here we agree perfectly with v. Graefe—iridectomy in glaucoma is a purely empirical operation, whose action *cannot* be explained, why should we not succeed, in a purely empirical way, in finding for glaucoma another operative or medicinal cure which accomplishes just as much as iridectomy without its ill results? And is v. Graefe alone authorized, from his experience, to lay so much value upon the excision of the iris in the operation for glaucoma? At the end of his observations, carried on for years and from many points of view, he says (Graefe's Archiv, Vol. XV., 3, 113): "I have seen a *very large* number of eyes in which, in typical inflammatory glaucoma, iridectomy fulfilled its ascribed qualities but badly, and in which, however, a *lasting* cure was reached. The more sudden the cloudiness of the media with which the disease comes on, the more does the *real pith* of the operation seem to lie in the *excision of the sphincter of the pupil.*" . . . "This very fact may restrain the operator from too quick a resort to a second operation, *assuming it impossible for the first to be sufficient.*"

If now we have to give an entirely unprejudiced opinion as to the more probable cause of the cure in case of so imperfect an operation, viz.: the wound in the sclera, or the excision of a perfectly motionless sphincter in the acute stage of glaucoma (characterized by dilated and immovable pupil), it seems to me that the former assumption would have the greater probabilities in its favor.

If I say, "In order to heal glaucoma, the iris must be excised, or at least the sphincter," or if I say, "In order to heal glaucoma, the wound must be laid in the sclera," and if I go on to lay down the grounds why such a method of operation is necessary, then no glaucoma can be cured if the sphincter remains, or if the wound lies wholly in the cornea; and yet we have facts that contradict this flatly. Del Monte (Nagel's Jahresbericht, 1871, 276), for example, contributes a case where iridectomy was made so bunglingly, in a case of inflammatory glaucoma, that only a *narrow* piece of the *periphery* of the iris could be excised, and where vision was restored, although T. remained permanently less than normal. Laqueur's case (Jahresbericht, 1871, 284) proves that even with failure in *both steps* of the operation, glaucoma can be cured. In this case of acute glaucoma, S. $\frac{2}{3}$ was gained in the one eye, and had been maintained for two years and a half, although the iridectomy was done most bunglingly, *with the small external wound entirely in the cornea*, and the *largest part* of the corresponding sector of the iris remaining intact at the periphery. In the other eye of the same patient, glaucoma was cured, leaving S. $\frac{1}{8}$, although the wound also lay *wholly in the cornea*, the excision of the iris was very faulty, the SPHINCTER REMAINING INTACT, and near the wound a dialysis of the iris.

Schnabel also (these ARCHIVES, V., 379) has seen "Iridectomy control acute glaucoma as well when a pretty broad zone of iris remained at the edge of the pupil as when such a zone was left at the ciliary border," "provided, however, that the incision was placed beyond the corneal margin."

Such facts, and especially those advanced by v. Graefe, tell us clearly enough that *an excision of the iris is not necessary to cure acute glaucoma.* But the less prominent the inflammatory symptoms, the more indispensable the regular excision of the iris to the furthest extent possible from the edge of the pupil to the ciliary border. As v. Graefe says: "The regular artistic operation for glaucoma becomes so much the more indispensable, the more open the forms of cloudiness of the media, characterizing themselves by increase of tension."

I desire here to cite a case which was so much the more interesting to me, as v. Graefe himself declares that an *excision of the sphincter* of the iris is the essential, in the operation of *acute* glaucoma.

CASE XV.(*)—Joseph Wagner, æt. 53, December 20th, 1869; had noticed about three months before that he saw worse with his left eye, and that now and then "a shadow would pass over it, from below upward. I had examined the patient repeatedly during this period, and had the chance to watch the development of a total excavation in this eye. The curvature of the vessels at the edge of the papilla, which was at first not marked, developed at several points into a distinct bend, and we could demonstrate the falling backwards of a few twigs of the vessels of the papilla. When he came to the clinique, the exterior of the eye was wholly normal, T. + 1. Emmetropia, high degree of Pr. R. E., nothing abnormal shown by ophthalmoscope; L. E., the excavation already mentioned. S. $\frac{13}{20}$, field of vision not narrowed. When iridectomy upward was made, Dec. 21st, the patient was so unmanageable that we were glad to have gone through with the operation without seriously harming the eye. A piece of iris two mm. broad had been excised, but the *sphincter remained intact.* Healing went on without delay. I was also able to demonstrate in this case a real diminution of the excavation which I had watched from its first development. On accommodating for the edge of the papilla, the vessels on the papilla were seen distinctly, and T. decreased decidedly. Vision now increased, so that Jan. 9th, 1871, more than a year later, S. was almost $\frac{20}{20}$. Here, then, we had a cure of glaucoma simplex after an imperfect excision of the iris, something that is not too often gained by the most successful operations. I will add that, later, iridectomy became necessary for the right eye, and that I embraced this opportunity to correct the "fault of art" in the left eye.

Now when I lay down this proposition, that not only acute glaucoma, but even chronic and simple glaucoma can be cured as well by sclerotomy as by iridectomy, I beg not to be misunderstood. This much is fixed, that excision of the iris is not necessary to heal glaucoma; but by this I do not mean that every case of glaucoma can be cured by a scleral wound at the edge of the cornea. As experiments have shown, the scleral wound must have a fixed extent, it must not be too small, and moreover, as has long been known, scleral wounds at the edge of the cornea are not real scleral wounds, but lie for the greater part in the corneal tissue.*

Although sclerotomy has, as yet, gained but little recognition, and in Germany hardly an introduction, yet the future probably belongs to it. Therefore, it may not be superfluous here to give a detailed history of the operation.

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* See Schweigger, postea, page 210, and v. Graefe's Archiv, XIV., 3, 120, 1868.

II. *History of Sclerotomy.*

It is well-known that Mackenzie was the first to recommend sclerotomy in glaucoma (1830). He says : "The dissolved state of the vitreous humor, which my dissections of glaucomatous eyes lead me to consider as generally forming part of this disease, is always attended, at least in the middle stages of glaucoma, by an abnormal firmness of the eye to the touch, evidently arising from an over-distention of the tissues.

"It is probable that the aqueous fluid, which fills the place of the vitreous humor, becoming superabundant, promotes, by pressure, the absorption of the pigmentum nigrum, and completes the insensibility of the already disordered retina.

"As a superabundance of dissolved vitreous humor appears to form an essential part of the morbid changes observed in the advanced stages of glaucoma, it is not unreasonable to conclude that occasionally puncturing the sclerotica and choroid might prove serviceable by taking off the pressure of the accumulated fluid on the retina. The puncture should be made with a broad iris-knife at the usual place of entering the needle in the operation of couching. The instrument, pushed towards the centre of the vitreous humor, is to be turned a little on its axis and held for a minute or two in the same position, so that the fluid may escape."

But we are not to understand from Mackenzie's accounts that he had up to 1835* ever really performed the operation. His way of speaking of it, and his utter silence as to its results, tell us clearly enough that our supposition is correct.

Mackensie's procedure was indeed a so-called rational one ; it is the only *rational* one that had, up to that time, been suggested for glaucoma. But whether dangerous or beneficial, I could not say. It is, however, especially interesting to know that very lately a procedure identical with Mackenzie's has been proposed and even put into practice. Prof. de Luca presented a communication to the Royal Academy at Naples, in June, 1874, saying that as he had not found either iridectomy or sclerotomy (in a sense hereafter to be discussed) to serve rationally in curing glaucoma, he made an incision into the vitreous between the rectus externus and rectus inferior, with a small lance-shaped knife which was grooved along the centre of the blade so as to allow the escape of the serum of the vitreous. The instrument was to be withdrawn when the tension of the eye became normal. If needful, he would repeat the puncture several times, either by introducing a small silver sound into the opening, or by a new incision. He reported thirteen successful cases after this method.

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* A Practical Treatise on the Diseases of the Eye. 2d edition, 1835, p. 831.

The first recommendation, since Mackenzie's time, of a true sclerotomy (*i. e.*, a more or less extensive incision in the sclera without harming the ciliary body) was only conditional. "If it were possible," said De Wecker, in 1867, "to make a large incision in the sclera, near the edge of the cornea, without causing an adherence of the iris, we should abstain wholly from touching that membrane."

Stellwag was the first to report (1868) two successful results of sclerotomy in glaucoma. In two cases of chronic glaucoma of long standing, coming on with distinct resistance of the globe, he made a long incision very obliquely through the whole thickness of the anterior scleral zone with a broad lance-knife. In one eye he made only a simple sclerotomy, in the other, a broad segment of iris was excised according to rule. The same result was gained in both eyes, viz., a similar and very considerable decrease in the palpable hardness of the globe, and disappearance of all the symptoms referable to an increase of intraocular pressure. These results continued through an observation lasting many weeks. Stellwag explains the efficacy of simple sclerotomy in that the stipulated condition of glaucoma lies in a rigidity of the capsule of the globe, and in the disturbance of circulation in the interior of the eye thereby caused (the resistance being chiefly in the *outer* layers of the sclera, while the *inner* layers retain a certain amount of elasticity), and that by the insertion of a more yielding cicatricial layer of connective tissue into the sclerosed tissue of the sclera, as is to be brought about by sclerotomy, the loss of elasticity in the capsule of the globe is to some extent compensated for, and likewise the circulation in the interior of the eye is again reduced as near to normal as is possible.

De Wecker again brought up the question of simple sclerotomy in a theoretical way, and without mentioning Stellwag's observations, at the Heidelberg Ophthalmological Society in 1869. He said that the result of the operation for glaucoma did not depend upon the size of the portion of iris excised, but only upon the position and extent of the incision in the sclera. The cystoid cicatrix, or one even less solid, was, as he had observed in glaucomatous eyes, important for a subsequent filtration of the aqueous, and so for a continuous lessening of intraocular pressure.

Under the title : "Whether Iridectomy is indispensable for gaining a Cure in Glaucoma" (Annali di Ottalmologia, 1, p. 200) Quaglino published (1871) the results gained by simple sclerotomy in five cases of glaucoma.

Case I.—A man, æt. 43, with glaucoma absolutum R. E. Anterior chamber shallow ; pupil slightly dilated, *motionless*, *greenish*. T. increased. No perception of light. L. E., T. less than in R. E., but above normal ; anterior chamber shallow ; fingers can be counted; F. contracted. R. E., simple sclerotomy outward, the incision passing obliquely between the lamellæ of the sclera into the anterior chamber. No prolapse of iris. L. E., iridectomy. Patient was discharged seven weeks later. Result : R. E. (sclerotomy), anterior chamber *normal* in depth ; pupil *black*, *movable*, *normally wide ;* T. *normal ;* no perception of light. L E. (iridectomy), T. normal ; vision improved, but F. has not enlarged.

Case II.—A man, æt. 61, whose eyes offer symptoms much like those just described. R. E. blind, iridectomy. L. E. still counts fingers at a few feet, but as if through a mist ; sclerotomy outwards. The sclerotomy causes a prolapse of iris. Two calabar discs were laid into the conjunctival sac, and a light pressure bandage applied. Three days later, T. normal in both eyes. The iris, which had not returned to place, was punctured and then touched with a bit of pointed lapis. Seventeen days later, T. in both eyes normal. L. E. counts fingers without the mist, pupil transversely oval and drawn outward toward the somewhat cystoid cicatrix. Periorbital neuralgia and hemicrania, which at one time had been felt now and then on the right side and later on the left, did not return after the operation.

Case III.—A man, æt. 52, had had an attack of acute glaucoma five months before in R. E., which now shows symptoms of subacute glaucoma, such as "enormous tension," "insensibility of cornea and *conjunctiva*," mere perception of light. Broad iridectomy upward and outward. Four weeks later, fingers counted eccentrically and with difficulty. T. somewhat less, but above normal. Patient returned in fourteen days with cloudiness of the media, and only perception of light in the inner portions of the retina. *Sclerotomy* inward, and the prolapsed iris replaced by Daviel's spoon. Two days later, T. much lessened. The prolapse (which seems to have returned) was punctured with a needle and touched gently with lapis. Five days later, T. subnormal. The patient was discharged a fortnight later, with a slight cystoid cicatrix in the sclera, pupil transversely elliptical, black. T. subnormal, and the eye counts fingers eccentrically.

Case IV.—Bagnoli, æt. 48, had a successful iridectomy in 1869, for glaucoma of R. E. In January, 1871, a similar attack in L. E. March 8th, 1871, he was received into the clinique with all the symptoms of subacute glaucoma. Fingers through a cloud at 3′ or 4′. F. not narrowed. Sclerotomy inward and slightly upward with a curved lance-knife. Instant prolapse of iris, which was, however, reduced by extending the scleral incision with a pair of scissors. Two calabar discs in the conjunctival sac. March 10th, renewed prolapse of iris. T. excessively subnormal. Two days later, "cicatrix complete," with the iris adhering thereto, and the pupil drawn towards that side. Media clear; fundus oculi normal, excepting one retinal extravasation; no pulsation of vessels. T. "evidently" subnormal, no neuralgia, objects clouded by a faint haziness. March 24th, patient discharged. T. a trifle subnormal, and fingers are counted without any surrounding mist.

Case V.—Rosa Brandalim, æt. 56, has complete blindness R. E., in which, judging from the description, there are the usual signs of absolute chronic glaucoma. Two calabar discs were laid into the conjunctival sac, one hour before an outward sclerotomy. But there was a prolapse of iris, which was excised radiatingly with scissors, and replaced. On the third day, the globe looks normal, pupil irregular in the direction of the incision, T. considerably lessened. Five days later, T. normal, sensibility of cornea normal, pupil slightly elliptical, and drawn somewhat toward the scleral cicatrix. No more neuralgic attacks.

To sum up: 2 (Nos. 1 and 5) sclerotomies in eyes blind from inflammatory glaucoma; 3 (2, 3, and 4) in eyes with vision diminished by inflammatory glaucoma.

In one case only (1) was there no prolapse of iris; prolapse in all the others with cystoid cicatrix (2 and 3), or healing of iris in wound (4 and 5). The glaucomatous symptoms ceased in all, and once (3) sclerotomy accomplished what iridectomy could not. As to the action of sclerotomy, Quaglino, in *this* paper, leans wholly on v. Stellwag's assumptions. Further light was thrown upon sclerotomy by De Wecker's letter to Quaglino (Annali, 1, 392), then by De Wecker's report at the Heidelberg Association in 1871, and finally in Martin's report of De Wecker's clinique for the last six months of 1871. Quaglino also makes a second report in the shape of a letter to De Wecker. From this we learn that Quaglino, after previously laying a few calabar discs in the conjunctival sac, penetrates with a broad, curved lance-knife at a distance of 2 mm. from the edge of the cornea, obliquely through the sclera into the anterior chamber, to the extent of one-third of the length of the blade. In order, then, that the iris may not prolapse when the aqueous flows off, the handle of the knife is to be raised a trifle, and then, while withdrawing very slowly, the flat of the blade is to press gently upon the iris. But even then there may be a prolapse. If so, the wound is to be enlarged in both directions, by means of scissors, and the prolapse reduced; or, if that fails, the prolapse is to be cut in the direction of the radiating fibres, in which case an adherence of the iris is quite unavoidable, and it is followed by a dragging of the pupil towards the place of the incision. But if the prolapse occur only on the following day, it must be punctured at once, and oftentimes repeatedly, the result being a cystoid cicatrix. Quaglino, however, assures us that "when the step of pressing gently upon the iris is rightly performed, a prolapse is rare." He has performed sclerotomy on the same eye two or three times, and at different points on the edge of the cornea, in order to obtain a decided decrease in intraocular pressure.

In order the more surely to avoid a prolapse, De Wecker recommends the following procedure: Make the incision with Graefe's knife as if you were planning an upward flap of 2 mm. After complete counter-puncture, continue the incision until two-thirds of the section are made. Before withdrawing the knife, lift the wounds open by bending the edge of the knife slightly forward, and so let the aqueous escape slowly. At this moment the pupil sometimes rolls a trifle over the back of the knife, but the knife hinders a prolapse. When the pupil has at last contracted, after the escape of the aqueous, and the iris lies in contact with the cornea, the knife is to be withdrawn very cautiously from the wound.

If, as exceptionally happens, the iris falls forward into one of the lateral incisions, and cannot easily be replaced by a small silver sound, the wound should be enlarged at once and the sclerotomy changed into an iridectomy. It is here that De Wecker does not follow Quaglino's principle, to complete the sclerotomy at all hazards; for if the section in the sclera is the one essential step in the glaucoma operation, then, on account of the subsequent tearing and irritation of the iris, we must avoid as much as possible any adherence of the tissue of the iris, such as a prolapse will cause. To guard against a prolapse after the operation, we must resort to calabar, pressure bandage, and the greatest possible rest. According to Martin's report, De Wecker operated seven times in this way in 1871. The cases were all of absolute glaucoma, and the aim was to remove the disagreeable inflammatory symptoms. The results were identical with those that iridectomy would have gained. There was but one prolapse of iris (on the tenth day), and that happened in the eye of a patient who left the wards on the sixth day after the sclerotomy. In spite of these favorable results, Martin thinks that sclerotomy will scarcely supplant iridectomy, " whose practice, already so common, has revealed prodigious effects and entire harmlessness." He adds, in a note, that experiments made at Utrecht with sclerotomy in cases of glaucoma have yielded good results. In the report of the Utrecht Hospital for 1871, I find accounts of two satisfactory sclerotomies in glaucomatous eyes.*

The experiments with sclerotomy in glaucoma were continued. The Annali di Ottalmologia (1872) have papers on sclerotomy by Rosmini, De Magri, Chislat and Simi, and the Archivio di Oftalmologia (1872), has " A Case of Glaucoma cured by Sclerotomy " by Morano.

Rosmini made a sclerotomy in the eye of a woman, æt. 66; R. E., chronic glaucoma, quantitative perception of light; L. E. sees large objects. During the operation, like Quaglino's, there was prolapse of iris in both eyes; this was reduced by the operator closing the lids and rubbing gently and methodically towards the incision in the sclera. The glaucomatous symptoms disappeared, and a few days later, " the patient certified to her complete restoration of vision."(?!) The patient returned five weeks later with glaucoma in both eyes, and only indistinct shadows of persons and very large objects were visible. Sclerotomy repeated as before, outward and above the first spot chosen; prolapse of iris as before, and as before removed by rubbing the lids and placing calabar discs into the conjunctival sac. The aqueous being renewed, the iris in both eyes fell into the wound. No bandage was applied, lest the effect of the relaxation of the sclera should be neutralized, lest the iris should press further into the wound and adhere, lest the action of the calabar should be hindered, and in order that an iridectomy could be made if it should eventually prove necessary. On the next day, indeed, a portion of iris had to be cut off. Wound healed in both eyes. As to the action of the operation, the accounts are very inexact. It is only said that the small colobomas did no harm to "the reacquired acuteness of vision."

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* Nagel's Jahresbericht, 1872, 185.

Di Magri communicates:

Case I.—Barbaini, æt. 67, chronic glaucoma, R. E., perception of light. Pain being very severe, sclerotomy outward was made at once with a curved knife. No prolapse. Patient sent home *with a handkerchief over her eye*, and on the next day, both pains and appearances of glaucoma were gone. Fingers at 8″. Twenty-four days later, there was a renewed attack with pain. Globe stony-hard, and the sight gained by the former operation is all gone. Second sclerotomy outward above the first; no prolapse; cystoid cicatrix. The eye has mere perception of light. T. normal, and neuralgic attacks gone. *Eight months after the operation, the globe is still normal*, and leaving out the cystoid cicatrix, it does not differ from L. E.

Case II.—Testa, æt. 62, blind from chronic glaucoma. R. E., pannus, no perception of light; L. E., never had any sort of conjunctivitis, can distinguish objects indistinctly, but only in the early part of the day. Sclerotomy, L. E., outward with a broad lance-knife; a small prolapse which is reduced by calabar. Two days later, S. relatively very good, bank notes and small objects are distinguished. T. normal, anterior chamber shallow, in the lip of the wound a gelatinous intertissue tinted black with pigment, and finally a cystoid cicatrix. T. is still normal, ten weeks after the operation. "The patient is happy with her recovered vision."

As regards adherence or prolapse of iris, Di Magri says generally, that when simply a fold of the iris lies in the wound, its replacement can usually be effected by removing the patient from a bright light, by rubbing the eye gently, or by inserting a calabar disc. If these means do not cause the iris to return to place, then let it be drawn out and excised.

Simi obtained the following results from sclerotomy.

Case I.—A woman, æt. 47, suffered from an inflammation of the eyes for several weeks, and in a short time became, "as it were quite blind," and the case on examination proves to be glaucoma in the subacute state. R., T. +3; L., T. +2. Vision not accurately designated (by Simi). R., sclerotomy with v. Graefe's knife after Quaglino's method (should have said, after De Wecker's), and a pressure bandage of small pads of wadding with a strip of flannel applied. On the third day after the operation, T. normal, glaucomatous symptoms absent, anterior chamber of normal depth, S. $\frac{10}{20}$. The other (L.) eye was then operated upon in the same way with equal success. No relapse, three months later.

Case II.—A woman, æt. 40, with chronic glaucoma of one year's continuance. S., which is variable, $\frac{2}{20}$, when Simi saw her. Sclerotomy, prolapse of iris at once controlled by calabar. The anterior chamber gained its normal depth, the iris its mobility, and S. increased to $\frac{18}{20}$, almost normal.

Case III.—L. S., æt. 54, old glaucoma in R. E., perception of light. L., the disease is of later date. S. $\frac{4}{20}$. L., broad iridectomy. R., sclerotomy. The result was perfect in both eyes. Simi regards this case as of especial value for comparing the two operations, but he is silent as to what the *perfect* result really was; he tells us nothing as to the actual amount of vision regained.

Case IV.—Shows the action of sclerotomy in an eye affected with secondary glaucoma, after a disease of the uveal tract; there being a small scleral staphyloma upward. T. decreases very rapidly in the operated eye of this patient, æt. 21, sinks to T. =1; the patient, of whose sight before the operation we find no account, was able, after a few days, to tell time by the watch, "and continued to improve ever progressively."

Simi says that he knows the noteworthy history of a fifth case, in which his "distinguished friend," Dr. Pecori, had performed sclerotomy, but "will not anticipate the latter."

Morano operated on a case of chronic glaucoma of about ten years' standing. T. +3; R., S. $\frac{15}{20}$; L., $\frac{7}{20}$. After a renewed aggravation of the inflammation in this (?) eye, the patient consented to an operation (Quaglino's), which was performed without a prolapse. Ten days later, S. $\frac{12}{20}$, and still later S. $\frac{14}{20}$.

We follow up these Italian reports of sclerotomy by one from Spain, by Chislat, of Seville. This, however, proves but little, for, according to Chislat, these cases were all secondary glaucoma; but in point of fact, in three of these four cases there was violent inflammation of the eye, accompanied with extreme pain and increase of tension. (Kerato-iritis with hypopyon, trachoma with perforating corneal ulcer, iritis serosa after Graefe's extraction), and only once (Case I.) was there an attack of glaucoma in a blind eye with synechiæ; but sclerotomy, by means of a curved lance-knife, removed the pains and the hardness of the globe.

The question of sclerotomy in glaucoma was also discussed at the International Ophthalmological Congress at London, in 1872. Quaglino speaks favorably of sclerotomy from his own experience.* He reports a new case in the left eye of an old man where sclerotomy was made to control chronic glaucoma. Two months later, a second sclerotomy on account of a relapse, and a month still later, an iridectomy upward. This last operation stopped all painful symptoms. "A third sclerotomy might also have brought about a cure."

It seems noteworthy to me that, while Quaglino, in his first report, basing his views upon those of v. Stellwag and De Wecker, opposes iridectomy from rational grounds, he now shows that as little light has been thrown upon the curative action of sclerotomy in glaucoma as upon that of iridectomy. His opinions have been changed by Schweigger's explanation that v. Stellwag's supposition of an elastic scleral cicatrix is inexact. Here are Schweigger's words: † "Even with the most peripheral incision, only a small portion of the wound lies in the sclera, by far the greatest part thereof lying in the cornea, and as I have convinced myself by anatomical researches, these wounds, when running a normal course, do not at all heal by the interposition of a new-formed tissue, but by direct union. Besides that, we do not look upon common cicatrices as more elastic, but as less so than normal tissues."

Secondi follows Quaglino,‡ and speaks favorably of sclerotomy which he performs after Quaglino's method. He finds no difficulty in avoiding prolapse of iris, by withdrawing the knife slowly and then applying a bandage. He made sclerotomy, at first, only in eyes blind from glaucoma, and had the satisfaction of seeing a noticeable lessening of the symptoms, and a continual improvement during a period of observation lasting several months. In other cases, Secondi made an incision at least 7 mm. long, with a small, peculiarly shaped linear knife, just beyond the ciliary body and into the conjunctiva and sclera, without, however, opening the cavity of the globe, or even pressing through to the choroid. In one of these cases, which Prof. Schiess, of Balse, also saw, there was not only a decrease of the glaucomatous symptoms, including a pathological increase in pressure, but the patient, who, before the operation, had mere perception of light, could count fingers at 50 cm. a few days after the operation. This improvement, however, lasted but a few weeks, owing to a progressive atrophy of the optic nerve, but T. did not increase thereafter. Secondi therefore, from this fact, regards the scleral wound as the one factor, and from other experiments, the evacuation of the aqueous as the second factor in the curative action of iridectomy.

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* In the English report, Quaglino speaks of seven cases of his own, besides the two of Magri's (p. 200)—then (p. 201) of nine cases and two of Magri. In the French report, the contradiction is still greater, for there he is made to speak of seven cases, including two of Magri's (p. 197), and then again (p. 199) of nine cases and two additional.

† Augenheilkunde, 1st edit., 1871, 511; 2d edit., 1873, 537; 3d edit., 1875, 530.

‡ Report of Ophthalmological Congress. English edition, 202; French edition, 199.

De Wecker, who first proposed sclerotomy, has, in later days, by no means assigned its expected rank to the operation. In his report, cited previously, as well as in his later papers, he speaks of sclerotomy as only applicable in absolute glaucoma. In his "Clinique Ophthalmologique, 1872, p. 6," he cites four cases, and says expressly that sclerotomy is to be resorted to in cases of absolute glaucoma only where the pains demand surgical intervention. In his report for 1873 (pp. 5 and 14), there are but two sclerotomies, and these are made void by the proposed rule, that, "in all cases where we have to maintain a certain amount of vision and to widen the field of vision, iridectomy is to be performed," because so long as the iris is not plainly atrophied, iridectomy can be performed more easily and more safely than sclerotomy, in which, under such circumstances, the iris may adhere to the wound. But, on the other hand, if the tissue of the iris be extremely atrophied, it is difficult to excise it accurately, and to get a good union of the wound, while simple sclerotomy offers an excellent result. "Sclerotomy, therefore, will be the operation *par excellence* in absolute glaucoma." Sclerotomy is far preferable to the enucleation of amaurotic glaucomatous eyes. The action of sclerotomy in removing pain and glaucomatous symptoms in absolute glaucoma is illustrated by the case of a woman, æt. 67. De Wecker's later reports give five sclerotomies in 1874, and four in 1875.

Then came the Drainage Theory. But from a letter that De Wecker was so good as to write to me (Oct. 7th, 1877), I learn that he has tried sclerotomy again, and in glaucomatous eyes that still *see*. But in his paper "On Glaucoma,"* there is only slight mention of a *special* case of a colleague with glaucoma simplex in his left eye, and who writes three months after the operation, that he is "extremely satisfied with the result which he believes he can consider as definite." De Wecker does not now use Graefe's knife, but a sclerotome 2–4 mm. wide and with a lance-point, so that he may cut as deeply as possible into the trabecular tissue of the sinus of the anterior chamber, so as thereby to open the excretory passages.

I know but little as to sclerotomy in France. Grandclément (Lyon Médical, No. 35, 1875) performed a successful sclerotomy in an eye blind from glaucoma, and suffering from a relapse with violent pain.

If we cross the channel, we find the English busy with sclerotomy in 1876. Bader says that by sclerotomy we may solve the problem of removing abnormal tension of the globe, by making an incision through the sclera, just in front of the insertion of the iris. "A permanent communication between the aqueous chamber and the subconjunctival space adjoining the scleral wound is the desired result."† He cites these four cases.

Case I.—A man, æt. 65, has acute glaucoma; R., T. increased, but not measurable on account of conjunctival chemosis; mere perception of light. L. lost its vision in twenty-four hours, fifteen years ago, from an attack of glaucoma. T. + 2, cornea cloudy, iris immovable, ciliary staphyloma, no perception of light.

Sclerotomy in both eyes six days after the inflammation in R. E.; patient under anæsthetics.

Three months later: T., R., $-\frac{1}{2}$, slight *prominence* of the scleral incision, *pupil drawn upward as if the eye had undergone iridectomy;* conjunctiva and cornea normal. "Good aqueous chamber," papilla whitish, vessels thin, not interrupted. F. good, can tell time on a watch at 10″, with a convex lens.

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* Klin. Monatsb. für Augenheilk., May, 1878; also in Therapeutique Oculaire, I., 383.

† Royal London Ophthal. Hospital Reports, VIII., 3, 1876, p. 430.

L., T. $-\frac{1}{2}$, considerable prominence of conjunctiva above the scleral incision (conjunctival staphyloma). *Pupil displaced upwards*, good anterior chamber, portions of iris visible, no pain, no perception of light.

CASE II.—Madame B., æt. 75, grew blind suddenly, R., ten months ago. She cannot read with the other eye, but can find her way about. Cataracts in both eyes; R. fully formed. Both eyes T. +1, and with the other symptoms of chronic glaucoma.

September, 1875, anæsthetics administered, sclerotomy in both eyes.

Dec., 1875, R. E., T. −1; L., T. normal. Corneæ transparent, good anterior chambers; in L., the incision looks like a dark line; in R., it is slightly staphylomatous. Pupils very narrow, especially L. Cataract increasing, time can be made out on a watch, F. is good.

CASE III.—Acute glaucoma R., lasting three days in a woman, æt. 65. This same eye had suffered from glaucomatous symptoms for years. T. +2; only perception of light. On this same day, the sight in the other eye began to decrease rapidly, so that only fingers could be counted, T. +2. Pupil somewhat dilated (no further account of this [L.] eye).

Sclerotomy in both eyes under narcosis. Nearly three months later, T. $-\frac{1}{2}$ in both eyes. The place of the incision slightly bluish, prominent, slight œdema of conjunctiva over the place of incision; pupils clear, *drawn slightly upwards;* good anterior chamber, no excavation. R. with $\frac{1}{15}$, L. with $\frac{1}{24}$, read Snel. $2\frac{1}{2}$ (at what distance?).

CASE IV.—Total staphyloma of the iris in the eye of a patient, æt. 24. T. +1; broad sclerotomy. Three weeks later, T. $-\frac{1}{2}$, cicatrix in sclera semi-transparent. Staphyloma wholly disappeared, and in its place a plane surface, blackish-brown. Same state two months later.

To these special cases Bader adds some general remarks on sclerotomy. He has employed it for the last three years in many cases where other operators would have performed iridectomy, and in some where they would have employed enucleation. He has had recourse to it especially in difficult cases of glaucoma where an iridectomy would have been difficult, or where subsequent loss of vitreous was to be feared. In most cases he used anæsthetics, and yet in several unfavorable cases he had dispensed with them successfully. Sclerotomy is to be made on the right eye with Graefe's knife, on the left eye with a bent cataract knife, so that the operator stands behind the patient and operates on both eyes with the right hand. The knife is pushed through the conjunctiva and sclera into the anterior chamber, as near as possible to and just in front of the insertion of the iris, then through the chamber without sparing any part of the iris that it may meet with, and again pushed out, as nearly as possible at and just in front of the insertion of the iris, and through the sclera and conjunctiva. The flap in the sclera is then to be finished just as in a cataract extraction, not rapidly, but gradually, especially when only a small bridge of sclera remains, so that the knife comes out through the sclera and under the conjunctiva "without any jerk." The blade of the knife is now to be laid flat upon the outer surface of the sclera, the edge turned backward, and while withdrawing the knife slowly from the subconjunctival space, some conjunctiva is to be freed from the sclera. This conjunctival bridge should spread out over the wound in the sclera as widely as possible. The aqueous now flows off beneath it, and there is sometimes a prolapse of the iris. The extent of the scleral wound amounts to almost one-third of the circumference of the cornea. Sclerotomy can be made in various directions, but it will be best upward. A sclerotomy behind the iris or through the ciliary muscle might be followed by atrophy of the globe. The usual result of the operation is an immediate decrease in T. in the most hopeless cases of glaucoma. The after-treatment is the same as for iridectomy. The only harmful sequence is the occasional development of a conjunctival staphyloma which, becoming troublesome, may demand operative interference. "But do not forget that here we have to do, not with a scleral staphyloma, but only with a staphyloma of the conjunctiva or conjunctiva and iris." In a postscript, Bader adds that, in five cases of such a staphyloma after sclerotomy, he gained very satisfactory results by the repeated application of flaxseed-meal poultices: pain, redness, and staphyloma disappearing rapidly, and the eye, *to all appearances already condemned to enucleation*, gained a healthy appearance, and its tension remained subnormal.

At the presentation before the Clinical Society of London of some patients on whose eyes sclerotomy had been performed, Spencer Watson spoke of the operation as he had performed it. His sclerotomy is really a keratotomy, for he said that the incision was confined simply to the cornea, and that the conjunctiva was barely touched at the places of entrance and exit of Graefe's knife. Watson prefers sclerotomy to iridectomy in all cases where anæsthetics are not applicable, and especially in chronic or subacute glaucoma, where the iris is atrophic, and the pupil permanently dilated. In Watson's opinion, the advantages of sclerotomy over iridectomy are the rapidity of the operation, the absence of hemorrhage into the anterior chamber, and of the danger of wounding the lens. In the discussion that followed, Higgins said that he had performed sclerotomy several times during the last two years, but had abandoned it; there is too much danger of getting too near to the ciliary region, and setting up sympathetic symptoms, as Higgins had in point of fact seen.* Nettleship also describes two cases of sclerotomy.†

And how has it gone with sclerotomy in Germany? Not very well. Stilling indeed, in 1868,‡ and later v. Hasner, from reasons advanced by v. Stellwag, had assented to the latter's view that in iridectomy the active element is the sclerotomy; but in 1869, when De Wecker brought up the subject for discussion at the Heidelberg Congress, an instantaneous and powerful opposition arose against the significance of the sclerotomy. By this I mean, not only the opposition with which De Wecker met at Heidelberg, and whose unanimity he expresses thus in his letter to Quaglino: "Mauthner was the only one there who did me justice;" but I mean above all the judgment which Albrecht von Graefe expressed at the end of his last great and memorable paper: "Contributions to the Pathology and Therapeutics of Glaucoma," § as to the way in which iridectomy acts: "As to the theory of the glaucoma operation, no progress of importance has been made in spite of many attempts. In all discussions on this point, the old hypotheses mostly are dragged forward; little satisfaction as they give in explaining existing facts. *The most unfortunate of all, that which refers the effect simply to the wound in the capsule of the globe*, is brought forward periodically, decked out in some new formula, and recommended for adoption. Fortunately for glaucomatous patients, *practice* marches forward independently upon the foundation of *empirical* principles; some time surely she will greet the confirmation of a tenable theory without in the mean while letting herself be led astray by transient hypotheses."

In the following year (1870), and even before sclerotomy had been especially practised from other points of view, v. Stellwag,‖ without departing from his opinion as to the chief *rôle* played by the scleral incision, denies all practical value to the operation, and even dissuades us from its use : "The excision of a sector of the iris is of secondary importance in the much-sought-for cure, and yet it is in so far *urgently to be recommended in all cases*, as the simple paracentesis of the sclera often at the moment of the operation, and still more often afterwards, gives rise to a prolapse of the iris, which, being usually irreducible, may lead on to an undesirable state of irritation, and, moreover, cause a disfigurement quite equal to that caused by iridectomy." It is no wonder, then, that other authors share v. Stellwag's doubts as to the practical value of sclerotomy. So little, indeed, is heard of the operation in Germany, that Schmidt, in his contribution on Glaucoma in Graefe and Saemisch's Handbook (Vol. V., 1, 124), cites only one case, and that one of his own. Here, with an acute glaucoma lasting already four weeks, there was extreme injection, anterior chamber very shallow, media cloudy, T. increased. Sclerotomy in De Wecker's method led to a cystoid cicatrix. Fourteen days later, the anterior chamber was still shallow, T. lessened, but still above normal, and again increased during the last few days. Movements of hand visible *close by* (outward and upward) before operation, now seen at 4′. Fundus oculi more clearly visible, moderate excavation from pressure. A year later, the eye had no signs of inflammation, but vision was wholly lost.

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* Lancet, I., 1876, 673. Boggs in "Receuil d'Ophthalmologie, 1876, 271. Ann. d'Oculistique, Vol. LXXVI., 263.

† Lancet, II., 1876, 504.

‡ Graefe's Archives, XIV., 3, 266.

§ His Archives, XV., 3, 252.

‖ Lehrbuch der praktischen Augenheilkunde, 4th edit., 356 et seq.

As to the general value of sclerotomy, Schmidt says that, from the Italian reports, it is remarkably evident that in certain cases sclerotomy not only improves the glaucomatous process, but cures it lastingly; but "that, on the whole, the balance of successful cases falls to the side of iridectomy;" and this is comprehensible, says Schmidt, when we think of the innumerable possible causes of that process which we include under the name glaucoma, *i. e.*, rigidity as well as decrease in elasticity of the sclera, irritation in the trigeminal region, engorgement of the venous current of the eye, and increase of pressure in the arterial system. All these may, under various circumstances, lead to increase of intraocular pressure, and so to glaucomatous diseases. According to Schmidt, it is just the excision of the iris that opposes many of these causes, unless he means secondary glaucoma with adhesion of the iris. "If we wish to kill two birds with one stone—to use a common but striking proverb—we must cling to iridectomy." The harmful results of a coloboma are almost null when we make it upward, and on the other hand, the lodging of the iris in the wound in sclerotomy is of positive injury. Finally, Schmidt agrees with De Wecker in recommending sclerotomy instead of enucleation in old cases of glaucoma, where tension still continued abnormally high.

Well then, and as Schmidt says, if I leave out my own cases in the Wiener Med. Wochenschrift, there is little to be heard of sclerotomy in Germany. Schnabel (see his paper in the present number of these ARCHIVES) describes the result of six sclerotomies with the lance, that he saw at v. Jäger's clinique. The readers of the ARCHIVES know of these cases, and besides they are of but little interest, for five of them were made in blind eyes, and in the sixth, only the hand could be seen at 6′; and again, they prove that sclerotomy does not remove the inflammatory symptoms. In only one case was the result of the sclerotomy equal to that of a "successful" iridectomy. But as Schnabel cannot tell wherein the performance of the operation in the one case differed from that in the other five, I should like to suggest that the sclerotomy was only made correctly in the successful case (although nothing is said as to the success of the operation *per se*), while in the other cases, the operation was incorrect. ("The sclera bulges forward at the inferior part of the incision, so that the globe looks like a truncated cone;" "the edge of the pupil bulges out a little in the direction of the meridian of the wound;" "the edge of the pupil is bulged out somewhat toward the wound;" "when the lance was pushed forward, the iris was pierced, and torn a trifle toward the pupil;" "the upper surface of the iris drawn towards the cornea in the region of the inner wound.") Now, I do not draw any conclusion from these facts, I affirm them only. As to the action of sclerotomy, Schnabel, as a strong supporter of the neuropathic school, thinks, if it is really followed by successful results, that it must act as a neurotomy; later he expresses himself much more hazily.

Hirschberg cites (l. c.) a case of sclerotomy after De Wecker's method, which was performed with technically good results. The curative result seems to me to have been a good one, only Hirschberg did not wait, but followed it up with an iridectomy eight days later.

Besides in all these papers, sclerotomy has been discussed theoretically and academically. Knies, who thinks that glaucoma owes its origin to a circular adhesion of the periphery of the iris to the cornea, regards the scleral incision as the essential point in the operation for glaucoma, and the excision of the iris as the unessential; while Weber, who to the opinion that the obliteration of the sinus of the anterior chamber is the essence of glaucoma adds the second, that the pressure of the origin of the iris against the periphery of the cornea, is stipulated for in a swelling of the ciliary processes, can see the beneficial operation for glaucoma only in an iridectomy, *i. e.*, "in an excision of a piece of the iris to its utmost periphery."

Schweigger (1877) says that the action both of iridectomy and sclerotomy is still unexplained. But he does not deny the possibility that sclerotomy may do as much good as iridectomy, although, as is plain from his representations, he has had no experience upon which to rest his views.

III. *Sclerotomy.*

Before communicating the results that I have gained by sclerotomy, I wish particularly to remark that we have to unite a distinct idea to the word sclerotomy—that we have to understand by sclerotomy a distinct operation, whose task it is to make an incision at the scleral border of the cornea, that shall penetrate into the anterior chamber, without causing a prolapse of the iris. When Hirschberg sees Mr. Bader perform sclerotomy at Guy's, "and must confess that he imagined the results of sclerotomy to be worse than the autopsy showed them to be," but that, after what he had seen in Bader's clinique, he could not hesitate for a moment to decide for iridectomy in comparison with sclerotomy,* and when, at the Berlin Med. Soc. (Nov. 21st, 1877), he appeals to what he has seen at Guy's, to prove that sclerotomy is unsafe, then any one not *au fait* in sclerotomy might fall into mistaken ideas. Bader's operation, which we described so accurately a few pages previously for the very purpose of comparison, is, as any one will see, a sort of monstrosity (if I may be excused the expression); an operation whose unfitness and danger can easily be seen from the standpoint of the irrevocable laws of operations on the eye, and which can best be illustrated by Bader's own account. If I should open one-half of the circumference of the cornea with Beer's knife, and let the iris fall forward, and from this bulging portion of iris excise a small bit, even that would be an "iridectomy;" but it would be altogether impertinent to speak absolutely of such an operation as an "iridectomy," and to confound its results with those gained by an iridectomy made according to rule. In the same way I will leave unmentioned all other operations recommended in glaucoma, such as: "The Puncture of the Sclerotic with a Needle" (Middleton, 1835; Richet, 1853; Lefort, 1876); "The Section of the Ciliary Muscle with a Knife or Needle" (Hancock, 1860; Heiberg, 1862; Pritchard, 1871; Ortowski, 1872); "Vose Solomon's Procedure" (1865); "Drainage" (Wecker, 1876); "Trepannation" (by Robertson, 1876); and "The Iridectomencleisis" (of Critchett, 1858; and Coccius, 1859).

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* The London Eye Cliniques. Deutsche Zeitschrift für prakt. Med., 1877, Nos. 27–31.

We have not yet succeeded in performing sclerotomy in the most suitable way. It makes a great difference as to whether we operate with a lance-knife and without a myotic, or whether we make the De Wecker section with the help of eserin. In the former case, the chance of success, *i. e.*, for avoiding prolapse of iris, is relatively small; in the latter, great. Then with sclerotomy, as with any other operation, it will be learned. Were not the best operators somewhat timid when they began to try Graefe's method, after being always used to the flap operation? Then again, it is not easy to make an iridectomy according to rule, but a sclerotomy according to rule is no less difficult. Therefore, I am astounded when De Wecker says in his last paper:* "Although in all probability, during the whole of my medical career, I shall continue to practise iridectomy as the safest operation in glaucoma, yet I am convinced that, as our knowledge advances, we shall supplant this procedure by one more simple and by far more logical;" and further on, l. c., 213, he says: "We must grant that it is difficult indeed, especially in patients in whom we have at stake the preservation of some vision, to experiment with new procedures, when we have already at hand one which exhibits a powerful curative action. *Therefore, so long as a bold operator shall not have devoted himself to the perilous task of proving that*

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* Klin. Mon. für A., May, 1878, 204. Also, "Therapeutique Oculaire," I., 378.

we can obtain an equally powerful action with sclerotomy and iridectomy, I advise you to cling to the latter procedure. De Wecker advises sclerotomy for hemorrhagic or absolute glaucoma only. In sclerotomy we have to fear a prolapse of iris, or the adherence of some fibres of the iris in the wound, not so much because that would hinder the healing process of the wound, but on account of the well-known sequences of the adhesion."

Now this is perfectly justifiable; but if we pass in review all glaucoma iridectomies, and all iridectomies in Graefe's operation, would there then be so very small a percentage of cases in which we could see a prolapse of the iris, or from the stretching and pulling of the iris be able to diagnose its adherence in the wound? However, I have a very decided respect for prolapse of the iris, because in a sclerotomy for glaucoma, supplemented by prolapse of the iris, I saw ulceration of the cornea ensue.

As to the *technique* of sclerotomy, I will note the following important points: .

1st. *A one-per-cent solution of eserin sulphate must be dropped into the eye before the operation.* Eserin acts promptly in glaucoma simplex, and not only in those cases of absolutely normal pupil and iris, but where there is distinct enlargement and sluggish reaction of the pupil. Although a single instillation of eserin causes extreme contraction of the pupil, yet in the inflammatory forms of glaucoma the action is slower in proportion to the predominance of inflammatory symptoms. Where the symptoms are severe, we must use a drop every hour to gain the desired effect. If we have to make a hasty operation in acute glaucoma, we must be content with a moderate contraction of the pupil. Eserin is null in its action only when the pupil is wholly atrophied. But this is seen only in blind eyes, and it is in just such cases (atrophy of iris) that it is easy to avoid prolapse of the iris.

2d. *The operation should, if possible, be performed without narcosis.* My experience with anæsthetics in operations on the eye has not been very agreeable. In *adults*, I never use anæsthetics from choice. I have abandoned them even for enucleation, since I became convinced that the section of the optic nerve, so much feared on account of the pain associated therewith, during the section of the ciliary nerves, is not so very painful, and almost always less so than the first incision of the conjunctiva. In children, on the other hand, I have often found, at a time when the narcosis was complete and when the assistant in charge refused to carry it further, that, in spite of the perfect relaxation of the muscles of the extremities, and with complete insensibility of the eyes, the muscles of the eye were contracted tetanically, so that the eye became fixed upward and inward, or upward and outward, so that only by considerable exertion with the pincers could the eye be brought into, and maintained at the right position for the operation (extraction or iridectomy upward). I cannot solve the dilemma as to whether it is the more difficult to operate on children with or without narcosis. With such tetanic contraction of the muscles of the eye, a sclerotomy upward could not be made. The iris would surely be thrown into or even out of the wound. Hence, I leave narcosis aside in sclerotomy, unless there is absolutely no choice with refractory children.

3d. *If the patient is calm and reasonable, the section of the sclera is to be made upward*, otherwise downward, so that, if an excision of the iris become unavoidable, the coloboma may have its relatively favorable position. Should a second sclerotomy be needful, it should be made as nearly as possibly diametrically opposite the first. This I do from analogy, for, as von Graefe says, and, as I believe, with perfect correctness, a second iridectomy made diametrically opposite the first is to be regarded as much more advantageous than a second one *adjoining* the first, so is this to be regarded as true for sclerotomy.

4th. *Enter with Graefe's knife* at 1 mm. from the edge of the cornea, *as if about to make a scleral flap* (De Wecker). But when the anterior chamber is not too shallow, the section should be made as if for a flap higher than 2 mm. In order to reach the point of counterpuncture without wounding the iris, the point of the knife should traverse the anterior chamber in an arc, with its convexity outward.

5th. When the knife has made the counterpuncture, *it is to be pushed slowly forward*, so long as the iris tends to move toward the counterpuncture; then, still continuing the incision, the knife is to be withdrawn somewhat, so that the iris is drawn out from toward the point of counterpuncture and so pushed toward the opposite side. The operation is to be ended in the *slowest possible manner*, and with a sawing motion of the knife. In this way, and with eserin, a prolapse of the iris in front of the blade of the knife will be avoided. We may observe sometimes that the to-and-fro movement of the knife across the iris causes the tissues on the surface of the iris to stretch apart, so that we see, during the operation, small black specks (specks of uvea), but when the iris has regained its normal plane after a cure, these are no longer visible. Possibly, the speck means a hole in the iris, but after healing I have never been able to throw light through by a mirror. No disadvantage of any sort arises therefrom.

6th. *The flap is not to be completed* (De Wecker). The higher the flap planned, the broader the bridge to be left behind, and the greater the guarantee against prolapse of the iris.

7th. *The sum of the length of the two incisions exceeds the length of the incision in simple iridectomy.* Arlt says * that, with increase of tension, the outer wound in iridectomy must measure 6–7 mm. We sometimes find larger outer wounds in iridectomy, even to 8 mm. in length. If we take the radius of the base of the cornea as 6 mm. and enter at 1 mm. from the edge of the cornea, making a scleral flap 2 mm. high, then the linear measurement of the external wound in the sclera will be 10.8 mm., and with a flap of 3 mm. high, not less than 13.5 mm. Hence, by making a flap between 2 and 3 mm. high, we can easily gain a scleral wound with a total length of 10 mm., in which, although each of the scleral incisions measures only 5 mm., yet we still have favorable relations against a prolapse of iris. Sclerotomy gains immensely in importance when the circumference of the cornea is distended abnormally. I shall cite a case on this point. An eye with hydrophthalmus has a largest corneal diameter of 18 mm. It is well known how dangerous iridectomy is to such eyes, so that, unless we desire to cause atrophy of the globe, it seems almost inadmissible. *On the other hand, we should not forget that, since a fixed extent of the scleral or iris section is needful to cause decrease in tension, the results gained by iridectomy in an hydrophthalmic eye are illusory.* If the diameter of the cornea were originally 12 mm., and if it were distended to 18 mm., then it is plain that the periphery of the cornea would increase, so that a scleral arc of 8 mm. would now correspond only to one of 5.6 mm. in the normal eye. But if in such an eye we make a Wecker's sclerotomy, the length of the whole arc (flap 2 mm. high) has an extent of 12.85 mm., and with 3 mm. flap, 16 mm., and with 4 mm. flap (this even is possible with the extraordinary depth of the anterior chamber, and without fear of collision with the iris) an extent of 18.5 mm. Hence we can make a scleral section of such size that it corresponds in size to one of 9 or 10 mm. in the undistended eye.

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* Graefe-Saemisch, Handbuch, III., 335.

8th. *The knife is not to be removed from the eye until the aqueous has entirely escaped.* To gain this, we must sometimes, after finishing the incision, turn the blade of the knife somewhat toward the cornea (De Wecker). Then the knife is to be pressed gently against the iris, and withdrawn very slowly from the eye.

9th. After instilling another drop of eserin, a *regular tight bandage* (with three or four ascending turns) is to be applied. After a few hours, this is to be renewed, so as to look for a prolapse of iris. Then eserin is to be applied again. Some bandage like this is indispensably needful. If we lay a simple flannel bandage over the eyes, we have no guarantee that we have done everything to guard against a prolapse at a later date.

10th. The patient is to rest quietly in bed for 48 hours. Prolapse of the iris can be avoided by following out this method prescribed. The more we practise the operation, the more sure we shall be of doing it according to rule. There is indeed no sure guarantee against a prolapse. If it ensue, it should be replaced by a vulcanized rubber spatule, or by Daviel's spoon, or in this way, viz., seize the prolapse gently with a pair of forceps—hard rubber branches are perhaps preferable to metallic—push it back into the eye, and before withdrawing the pincers, let the branches open slowly, and then as it were smooth down the iris. But if, in spite of this, the prolapse recur, then, although I have already seen complete prolapse disappear wholly, at a later date, by the help of eserin and a tight bandage, I would advise the excision of the iris, since we cannot rely upon its spontaneous replacement. This excision should be done simply without enlarging the wound of the sclera concerned. If we find a prolapse when the bandage is renewed, then we should excise it at once.

These are the rules that I would suggest, from my experience with the operation.

I append now the history of those cases where I had opportunity to make a sclerotomy. They are quite full, because many of the points will hereafter come up for discussion.

I. PRIMARY GLAUCOMA.

A. *Glaucoma Inflammatorium Acutum.*

Case I.—Mr. E., æt. 71, Aug. 14th, 1877. Powder exploded into R. E. a long time ago, and the characteristic pigment is still present about the eye and in the conjunctiva. In his youth this eye had some inflammation which, as I was able to assure myself after curing the glaucoma, had left several facets as large as a pin's head, stretching across the pupil. The L. E. had suffered still more in former years from "inflammation," to relieve which, 18 years ago, an iridectomy was advised, and made outward and correctly. A few weeks afterwards, this eye could read common newspaper print, but later it grew entirely blind. Eight years later it had severe attacks of violent and continuous pains which disappeared at last after the use of electricity. Subsequently, the eyes have been very quiet. About ten days ago, severe pain came on suddenly, R., and loss of sight, which was, however, restored the next day. The oculist consulted could see nothing wrong. Pain R. continued, and on the night of Aug. 13th–14th, acute glaucoma broke out. When I saw the patient at evening (14th), the violent pains had lessened somewhat, the eyelids were open, conjunctiva chemotic, cornea cloudy; lateral illumination revealing a remarkable striped haziness of the parenchyma, like that developed so often after Graefe's cataract incision. These stripes, of a whitish-yellow tint on illumination, ran from above downward, and at places were crossed diagonally by many dashes. Anterior chamber shallow; pupil wide and somewhat eccentric and fixed; fundus oculi invisible; globe very hard; counts fingers at 4″; peripheral F., not contracted.

L. E., cornea hazy from an old parenchymatous cloudiness, grayish-white, and also striped; anterior chamber deep; pupil much dilated; artificial coloboma upward and outward; iris reduced to a narrow rim. The opacified lens is dislocated downward. T. increased; no perception of light.

Aug. 15th, forenoon, sclerotomy downward (not upward on account of the pronounced chemosis of the conjunctiva); pupil previously contracted by application of eserin. Perfect success of the sclerotomy in spite of the very shallow anterior chamber.

With cessation of pain in the wound, the pains ceased wholly and did not return. The cloudiness of the cornea assumed a remarkable appearance. The stripes gave way to squares, so that in 48 hours the cornea looked like a chess-board. This disappeared by degrees, so that, at the end of a week, it was all gone. At no time was there any blood in the anterior chamber, which, after its restoration, was evidently *deeper* than before. A few adhesions formed between the iris and the anterior capsule. These loosened of themselves (atropine at no time being used), and left the corresponding pigment spots on the capsule. T., which was at first fluctuating, grew perfectly normal, so that L. E. was the harder.

Exact examination, 14 days after the operation: T. normal; cornea perfectly transparent, except four old central facets; anterior chamber deeper than is usual in a patient æt. 71; the tissue of the iris not yet normal, its fibres not yet wholly distinct; pupil dilated a trifle more than normal, not exactly round, *rigid*, remains of pigment on anterior capsule; the lens, although in diffused light an unusually intense reflex comes from the pupil, is wholly transparent, and so, too, the vitreous. No traces of extravasation in the retina, and the optic nerve is distinctly reddish, the wounds closed and no serous elevation of the conjunctiva. Testing showed that patient could read newspapers with his glasses, but not quite so clearly as before. Peripheral F. normal.

Four weeks later, about the same, only the fibres of the iris are now quite distinct, pupil is narrower, but not quite round and does not react to diffuse light. Patient reads J. 2 fluently, and with $+\frac{1}{12}$ spells J. 1 at 9″. I do not know what was the patient's vision before the outbreak of the glaucoma, although it must have been reduced by the central facets of the cornea. He says that *without* glasses he can see better near to than before. Emmetropia. He complains of a certain dazzling on reading poor print (newspaper).

October 8th, I found out that Mr. E. coud read J. 8 without a glass, and that the lenses which he had been using were the cause of the "dazzling," being too strong and having to be exchanged for $\frac{1}{20}$.

June 1st, 1878, patient seen again; in spite of the fact of unsuitable surroundings and repeated attacks of irritation, L., the right eye has been free from every trace of trouble. With exception of a moderate enlargement, and a trifle of sluggishness in the pupil, which is now round, the eye *is perfectly normal in every respect* (leaving aside the previously existing alterations). The remains of the iritis on the anterior capsule have disappeared.

B. *Glaucoma Inflammatorium Chronicum.*

Case II.(*)—George Knahler, æt. 56, who passed through inflammation of the brain, small-pox, and typhus in his youth, says at his reception, Jan. 17th, 1876, that until a year ago he could see remarkably well, then something "came over" his left eye, and while wiping it or rubbing it he discovered that his right eye was blind, or had but little sight. He remembered then that, three years before, he had suffered from severe pains in this right eye; that these pains had returned at various intervals and lasted through the night, but up to this time he had never tested his vision. In the spring of 1875, similar pains came on in L. E., but without any noticeable diminution of its sight. That summer, renewal of pain with inflammatory symptoms; vision became foggy, and colored circles were seen about the fire on the hearth and candle flames. Then the eyes became quiet until November. Fourteen days before Christmas, both eyes, L. especially, had violent inflammation, beginning at morning, lasting all day, but lessening so much towards evening that the patient could again open his eyes and convince himself that he still saw, somewhat hazily to be sure, but so as to read with his glasses. He could still read on New Year's Day, 1876, but since then the vision has grown worse, perhaps, as patient thinks, on account of the dazzling light reflected from the snow.

Jan. 17th, 1876, R. no perception of light, T. +2 to +3. Cornea slightly roughened and cloudy, its sensibility much lessened; ciliary veins around its circumference; anterior chamber shallow. Iris discolored, fibres obliterated, pupil dilated *ad maximum* and immovable. Lens opaque, swollen cataract, glistening like mother-of-pearl. L., S. $\frac{5}{200}$, not improved by glasses. Sense of light normal. Peripheral F. somewhat contracted upward and downward (least inward), reaching from point of fixation, upward 34°, downward 41°, outward 73°, inward 45°. T. +2. Cornea cloudy, roughened, partially insensible, ciliary veins congested, anterior chamber swollen; pupil moderately dilated; fixed. Fundus oculi can be lit up; but no details are visible.

Jan. 18th, sclerotomy (De Wecker) in both eyes.

Jan. 26th, operation successful, cornea perfectly clear; L., fundus visible, edge of papilla somewhat indistinct, *no* excavation. S. (with $+\frac{1}{30}$) $\frac{10}{30}$, and a few letters of XX. F. enlarged perceptibly in all directions, upward 50°, downward 53°, outward 80°, inward 50°.

Jan. 30th, T. both eyes normal. R. a trifle less than L. Media L. and cornea R. transparent. Sensibility of cornea as before the operation. In both eyes the conjunctiva is raised slightly at the points of puncture and counterpuncture.

Feb. 5th, S. (L. E.) with $-\frac{1}{24}$ s. $\overset{\frown}{\smile}$ $-\frac{1}{50}$ c. $=\frac{10}{20}$.

March 17th, 1877, 14 months after operation, patient has had same amount of sight ever since, and no pains as in previous years. Only once was there a transitory haziness of vision.

R., T. $+\frac{1}{2}$, *i. e.*, somewhat higher than normal. Cornea perfectly transparent; anterior chamber deep; cataract; no perception of light. A slight serous prominence of conjunctiva at the outer side of the wound, but no recognizable distortion of pupil; iris normal in color and structure.

L., T. normal; cornea transparent; anterior chamber somewhat less deep than R.; iris normal in color and fibres; pupil round, black, *reacts to light and shadow.* Lens and vitreous clear; edge of papilla somewhat indistinct, no excavation; papilla somewhat pale. The *inner* (medial) wound somewhat elevated. S. $\frac{10}{20}$, with + 18 J. 3 *fluently, while before the operation S. was only* $\frac{5}{200}$, *i. e., fingers counted only at a few feet.* Patient is green-blind; he recognizes all the other colors, even red.

CASE III.—Andreas Praxmann, æt. 62, Feb. 5th, 1876; was always healthy and with good sight. He lost R. E. in a brawl, two years ago. L. had still fair vision, but grew bad so quickly that, when seen first, July 6th, 1874, perception of light was lost.

R., atrophy of globe, the impressions of the insertions of the four recti muscles are visible, but the stump is quite hard to the touch.

L., T. + 2; cornea cloudy, so that the fundus is invisible; no noticeable anæsthesia of cornea. Pupil somewhat dilated. Three days later, the cornea cleared up, with exception of a thick spot of cloudiness just below the pupil. The pale-green papilla is seemingly surrounded by a narrow glaucomatous ring at the inner border, of which some of the vessels bend, some curve, and some run straight. More exact observation in erect image shows that the excavated surface does not correspond to the whole papilla, and that the apparent ring is really the edge of the papilla.

Feb. 13th, L., sclerotomy (De Wecker). Feb. 14th, anterior chamber restored, prominence of the conjunctiva at the place of the wound, T. lessened. Feb. 16th, T. normal, prominence less. Feb. 18th, T. as on the 16th, and blood still remains in the anterior chamber. No alteration in fundus oculi. Feb. 24th, T. again +. March 1st, T. much lessened, and almost normal. March 3d, patient transferred on account of variola.

C. *Glaucoma Simplex.*

CASE IV.—Anna Wastatter, æt. 48, Oct. 24th, 1874; always saw well far and near. The sight, L., had decreased gradually for three years, and lost entirely since New Year's Day. S. has also been decreasing in right eye for some months.

L., T. + 2, S. = 0; fine glaucomatous excavation.

R., S. = $\frac{20}{30}$, not improved by glasses. F. perfect, T. + 1 to + 2. Excavation beginning (curving of vessels).

Oct. 30th, sclerotomy (L.) downward with lance, no prolapse. R., iridectomy upward. Oct. 31st, incisions closed, anterior chamber restored.

Nov. 1st, T., in both, as before operation. Nov. 2d, L., T. noticeably lessened; R., T. unchanged. Nov. 4th, R., T. only slightly lessened; L. notably. *The left globe is much softer than the right.* Nov. 10th, R., S. $\frac{20}{30}$ with $-\frac{1}{24}$ c. Nov. 13th, R., iridectomy downward, with much hemorrhage into anterior chamber. Nov. 14th, anterior chamber almost full of blood. Nov. 20th, blood absorbed one-half, T. less than before.

Dec. 3d, S. $\frac{20}{50}$; with $-\frac{1}{14}$ c., axis vert., S. $\frac{20}{30}$ almost. Nothing pathological in fundus, except that the papilla is transversely oval in erect image.

March, 1877, patient wholly cured.

CASE V.—Romedius Buhlacher, æt. 64, Dec. 29th, 1873; has always seen well. In the spring of 1872, the bow spring of a mouse-trap struck both his eyes which grew red, the left eye being especially painful. He was a patient at the eye clinique for two weeks (notes lost), and is sure that, after his cure, he could with his left eye alone see the time on the clock in the church tower. Two months later, a second inflammmation came on in L., and it remained now blind. The right eye has been losing its sight since June, 1872.

R., a pterygium crosses on to the cornea from the inner corner of the eye and covers the pupil, with exception of a small part upward. Many facets on the cornea near the point of the pterygium; fingers counted at 8′.

L., T. increased moderately; a circular abrasion of cornea $1\frac{1}{2}'''$ diameter, upward and outward; anterior chamber deep; pupil dilated ad maximum, motionless; lens absent; hypermetropia with aphakia; atrophy and shallow but complete excavation of the optic nerve; quantitative perception of light.

Dec. 9th, iridectomy (R.) *outward* on account of the pterygium. L., sclerotomy upward and outward with lance-knife. Dec. 12th, R., pupil black, slit-shaped. Dec. 15th, R., S. $\frac{5}{100}$, fingers at 16′. L., T. but little decreased. Dec. 29th, R., cornea facetted extremely, S. $\frac{5}{100}$. L., T. *notably lessened.*

CASE VI.—Heinrich Kurzemann, æt. 74, June 21st, 1875, could see far and near six years ago. Since then his sight has been decreasing gradually up to a year ago; since then he has noticed no further loss of vision.

T., both, hardly at all abnormal, and yet L. is harder than R. Externally the eyes are normal, with complete arcus senilis in both. S., both, $\frac{3}{50}$; with $\frac{1}{30}$, $\frac{5}{50}$. Peripheral opacities in cortex of lens, the nucleus wholly transparent, but the image of the fundus slighty veiled. R., total excavation with a broad glaucomatous ring, which outward and downward measures $\frac{3}{4}$ P. D. L., only a hint at an excavation, but the *yellowish ring is very pronounced.*

June 23d, sclerotomy in both eyes inward and downward, with the lance ; prolapse of iris in both, replaced by pincers. June 24th, incisions in both eyes healed, anterior chamber restored, iris in normal position, and the pupil round. Very little reaction close to the wound. Pupils react promptly to light and shade. T., both, noticeably diminished. June 27th, T., which *had been a trifle subnormal in both eyes*, remained so at discharge, Sept. 9th, 1875. S. $\frac{10}{100}$.

Case VII.—Wolfgang Auberger, æt. 55, Oct. 20th, 1875 ; was hit on the right cheek two years ago, and on testing his sight immediately after, found that he saw but little with the right eye ; only fingers held towards temporal side. Vision has been decreasing, L., since winter, and the patient is bothered at always running against things to the right, and when holding his head up, at seeing nothing at all downward.

T., R. + 1 ; L., T. + 1 (?). Both corneæ are fully sensitive ; anterior chamber and pupils correspond to the patient's age ; the latter reacting fully. Media clear, total excavation. R., no perception of light ; L., S. $\frac{20}{200}$; with $-\frac{1}{50}$, S. $\frac{20}{50}$; F., perception of light $\frac{1}{300}$. The upper and outer quadrant of F. is chiefly retained. Measurements give, directly inward from point of fixation (90) only 8°, 100 inward and downward only 5½° ; 120, 5° ; 140, 4° ; 160, 3½° ; 180 (downward), 4° ; 200, 9° ; other bounds are (upward) 0—44, 39, 40, 36, 18 ; then 34 (140), 45, 63 ; 70 (270), 70, 60, 50, 42.

Oct. 26th, sclerotomy with *lance*, R., upward ; prolapse of iris, irreducible, excised. L., (sclerotomy) downward and inward, in which direction the pupil is somewhat drawn after the operation. Healing normal. Oct. 29th, T., L., decidedly lessened ; R., not so distinctly lessened.

Nov. 10th, T. nearly normal in both. L., without glass, S. $\frac{15}{200}$; with $-\frac{1}{50}$, $\frac{15}{40}$, with $\frac{1}{18}$ J. 5 at 10″.

July 29th, 1876, 8½ months later ; *pupil of left eye perfectly round*, T. *being at the physiological minimum.* S. with $-\frac{1}{40}=\frac{10}{30}$ (really $\frac{4}{12}$ with Schweigger's type). R., the excised iris adheres to the internal angle of the wound, T. somewhat higher than in the left eye.

Case VIII.—Josef Lindner, æt. 61, Nov. 16th, 1875, has noticed a loss of sight within a few years, especially R., and since last New Year's Day the sight (R.) has decreased rapidly.

T., both, + 2 to + 3. Nothing abnormal in the anterior segment of the eyeballs. Total excavation R., S. $\frac{5}{200}$, but with eccentric fixation.

F. not determinable with accuracy on account of eccentric fixation, and yet we can conclude that there is a decided contraction.

L., S. $\frac{20}{30}$ without glasses; glasses are refused; outer and lower quadrant of F. alone remains constant. Upward, and upward and inward, the defect extends to within 5° of point of fixation; 5 (0), 5, 12, 18; 18 (90), 17, 13, 22, 46; 44 (180), 50, 56, 60, 66; 60 (270), 62, 40, 27, 21. Perception of light $\frac{2}{112}=\frac{1}{56}$.

Nov. 25th, sclerotomy in both eyes with lance-knife. R., downward and inward; L., upward. L., calabar. Both sclerotomies successful. Nov. 26th, R., iris prolapsed into wound; L., wound closed, pupil perfectly round and narrow. Nov. 28th, R., conjunctiva bulged out at the wound, as large as a pea; no reaction. Nov. 29th, R., aqueous humor poured out under conjunctiva at lower equator of globe. Anterior lip of wound raised. Anterior chamber moderately deep. T. −1. Nov. 30th, L., pupil drawn slightly upward. R., fluid mostly gone from the conjunctival sac, but there is still a bubble as large as a pea at the wound. Cornea clear, iris drawn towards the wound, just as if a regular broad iridectomy had been made.

Dec. 1st, R., pain at morning, extreme ciliary injection, slight conjunctival chemosis, cornea clear; pupil dilated, black. 2 P.M., pains continue, cornea cloudy, pupil narrow, anterior chamber shallow, conjunctival chemosis. Iridectomy was attempted. After the anterior chamber was opened with the lance-knife, necrosed shreds of iris were removed from the wound; continuation of tight bandage, atropia, eight leeches to the temple. Dec. 2d, pus at periphery of cornea (ring abscess). Increase of conjunctival chemosis. No pains. Dec. 6th, increased chemosis, cornea all purulent, no pain. Dec. 7th, panophthalmitis.

Jan. 5th, 1876, R., cornea preserved, discolored, but transparent, crossed by vessels, quite flattened. Iris visible, pupil blocked up by a yellowish membrane. T. subnormal.

When light is thrown by the mirror upon the medial sclero-corneal boundaries, the patient perceives it, and projects it laterally, otherwise the perception of light is lost.

L., T. normal, pupil slightly drawn upward, no extravasations in fundus oculi, no remnants thereof; S., without glass, $\frac{20}{100}$; with $\frac{1}{40}$ c., $\frac{20}{40}$.

Aug. 20th, 1876, T. normal, S. with $\frac{1}{30}=\frac{10}{30}$ (Dr. Plenk, who saw the patient at Kitzbüchl, had no cylinders at hand).

March 19th, 1877, patient informs Dr. Plenk that his sight is as it was last August.

Case IX.—Josef Rottmayer, æt. 66, Feb. 13th, 1876; a branch hit his right eye thirty or forty years ago, and he then noticed that he saw hardly anything with L. For twenty-two years he had not seen the sun with this (L.) eye. Until fifteen years ago, he had had no pain in this eye, but then pains came on and with frequent relapses, both in the eye and around it. Until five years ago, the eye looked normal externally.

Five or six years ago, he began to see poorly with the right eye at evening. That is to say, when he came into a room at evening, everything would grow dark, but then clear up again.

L., T. +3, edge of lid reddened, conjunctival vessels and subconjunctival veins are much developed, slight cloudiness spread over the cornea; downward and inward a more marked, yellowish, and sharply defined cloudiness as large as a lentil; below and inward from this a blister as large as a millet-seed, filled with clear contents; anterior chamber moderately deep; pupils not dilated, edge of pupil irregular; cataract; no perception of light.

R., T. almost +3, globe externally normal, anterior chamber *rather deep* than otherwise; sensibility of cornea seems diminished, but it is higher than in the other eye, where also the sensibility of the cornea is not abolished. Media clear; deep, total excavation, with a glaucomatous ring, the breadth of which is equal to $\frac{1}{5}$ P. D.

S. $\frac{20}{70}$; with $\frac{1}{36}$, $\frac{20}{30}$; periphery of F. contracted concentrically; 0: 7, 5, 6, 11; 90: 13, 10, 10, 9, 9; 180: 8, 7, 5, 7, 7; 270: 10, 11, 12, 12, 7. Sensibility to light $\frac{1}{81}$; sensibility to colors normal.

Feb. 16th, Wecker's sclerotomy in both eyes; perfect success without prolapse. Feb. 27th, extreme cloudiness of cornea, L., with pain, had been present; but now the cornea is less cloudy (more so than at patient's reception), and the pain and redness have disappeared.

R., T. almost normal; anterior chamber moderately deep. S. $\frac{20}{50}$; with $\frac{1}{40}$, S. $\frac{20}{30}$ +A. F. is as before.

Aug., 1876, Dr. Plenk saw the patient at his home. R., T. normal, and even (physiologically) minus. With Schweigger's type, S., with $\frac{1}{20}$, $\frac{4}{12}$, and a few letters of 9.

May 7th, 1877, fifteen months after the operation, patient is seen by Dr. Plenk. T. +1 (?). Cornea sensitive; pupil moderately dilated, perfectly round, reacts slowly. S., with $\frac{1}{24}$, $\frac{10}{20}$ fully.

Case X.—Aloisia v. Troyer, æt. 60, Oct. 21st, 1875. R., no perception of light. L., S. $\frac{15}{30}$; with $\frac{1}{50}$, single letters of XX. at 15′. F. narrowed somewhat inward, to 43°, from point of fixation inward. T., R., +2; T., L., +1. Both corneæ wholly transparent and perfectly sensitive; pupils and anterior chambers narrow and shallow according to age; pupils round, react very promptly, R. only consensually. R., deep, total excavation. L., excavation beginning, as shown by curving and bending of vessels at edge of papilla.

Oct. 23d, sclerotomy (Wecker) on both eyes. R., pupil not wholly round; L., pupil round; calabar. Oct. 24th, both pupils round, anterior chamber restored, no reaction. Oct. 27th, T. in both lessened considerably.

Nov. 10th, S. as before operation; T., L., normal; R., somewhat higher than L.

Feb. 7th, 1877, fifteen months after the operation, T. almost normal in both eyes, R. somewhat more resisting. L., without glass, and in a bad light, S. $=\frac{15}{20}$ almost, *i. e.*, in glaucoma simplex for fifteen months, S. has not only not sunk, but even increased.

Case XI.—Andreas Draxl, æt. 69, July 2d, 1876; saw well until two years ago. Since then S. has decreased and remained about the same for two months.

L., T. +3; R., T. +2 to +3. Both eyes normal externally. Corneal sensitiveness not remarkably changed; anterior chamber not shallow; pupils reacting very promptly, and giving off an intense gray reflex, shading into green. Mirror shows post. polar cataract in both eyes, and total excavation of optic nerves. L., fingers at 6″, R., at 1′; light sensibility $\frac{1}{18}$; color sense destroyed, no shades of green recognized, and bright red declared repeatedly to be white.

July 14th, sclerotomy (Wecker) in both eyes, upward, pupils round. July 15th, R., anterior chamber restored, *iris bulging forward in the lateral wound.* Moderate ciliary injection, slight pain. Tight bandage. L., anterior chamber restored, wound closed, pupil round. July 18th, T., R., scarcely lessened. T., L., −1 (?) very decidedly. July 25th, R., ciliary injection except at lower third of cornea, and most marked at the spot of prolapse. Serous infiltration of conjunctiva over the prolapse, and the spot covered with vessels. The whole prolapse is 2 mm. high, 5 mm. long (equatorial diameter), 3 mm. broad (sagittal diameter). T. +1, +2.

L., pale, a trace of blood at the bottom of the anterior chamber; pupil reacts promptly, and is perfectly round.

July 28th, fingers counted (R.) at $2\frac{1}{2}'$, L., hesitatingly at $2'$.

CASE XII.—Joseph Redlich, æt. 54, Oct. 9th, 1876, noticed that he lost its sight four years ago. S. decreased slowly and has remained the same for a year. R. has suffered for a year.

R., T. + 1 (?); L., T. + 2. Cornea normally sensitive; anterior chamber moderately shallow; irides not much changed; pupils grayish-green, reacting to light and shade, L. pupil less promptly. Media clear; a yellowish ring surrounds the excavated papilla, downward and inward it is $\frac{1}{3}$ P. D., upward and outward $\frac{1}{5}$ P. D.; covered all over with remains of the choroid, with exception of the lateral borders which are surrounded by a sharply defined border of pigment. The epithelial pigment of the choroid is everywhere deficient.

S. is fluctuating, only eccentric, R. barely $\frac{5}{70}$. L. only fingers, sometimes $\frac{5}{200}$. F. not determinable with accuracy, nor sense of light. Sense of colors has not suffered noticeably.

Oct. 20th, sclerotomy in both, upward (Wecker). Hard work to avoid the iris. Prolapse in both eyes, especially R. *The prolapses cannot be replaced.* Calabar square after operation, in both eyes. Oct. 21st, wounds closed in both eyes, *both pupils perfectly* round, 2 mm. in diameter. (Before operation and without calabar, 4 mm. in diam.) Oct. 26th, pupils round, T., L., decidedly less. R. doubtful. R., S., $\frac{5}{100}$; L., S. $\frac{5}{200}$ (?).

Jan. 3d, 1877, patient received again into the clinique; T. as before the first sclerotomy; pupils moderately wide. R., S. $\frac{5}{200}$; L., S. $\frac{4}{200}$. Solution of eserin, one per cent, causes contraction *ad maximum* of pupils. The aqueous was drawn off by Pravaz syringe, and measured by Abbe's instrument showed an index of 1.3310. The perfectly clear aqueous held in the syringe contains, besides some epithelial cells originating from the penetration of the cornea, some pigment of the iris, but no single, round cells.

March 2d, sclerotomy downward in both eyes after eserin, no prolapse. March 3d, pupil slightly transversely oval. March 5th, both pupils perfectly round, anterior chambers shallow. March 14th, pupils somewhat narrower than before the last sclerotomy. S. unchanged, but the peripheral amblyopia seems to increase. T. not noticeably changed. March 18th, pupils react very slowly; patient refuses iridectomy.

I thought that I ought to propose iridectomy, but from my experiences in such cases, it was fortunate for the patient that he refused. The remains of sight had not suffered noticeably from the sclerotomies.

Case XIII.—Mr. B., æt. 74, Aug. 23d, 1877; in both eyes, anterior ciliary arteries very tortuous; corneæ cloudy in the shape of distinct parenchymatous spots, which look like the remains of previous inflammation. The sensitiveness of the cornea, especially in both upper halves, is visibly lessened, anterior chamber moderately deep, pupils wide, barely reacting, T. + in both eyes, R. higher than L. Fundus oculi not illuminable.

R., with $\frac{1}{12}$, J. 9 hesitatingly at 5″. L., with $\frac{1}{8}$, a few letters of J. 17. Both fields of vision free.

Aug. 25th, perfectly successful sclerotomy (Wecker) in both eyes, upward. Aug. 30th, pupil narrow (eserin instilled last, on Aug. 27th, at morning) and reacting. Cloudiness of cornea unaltered. T. in both eyes normal, the diminution of tension being very noticeable. S. unchanged, and patient goes back to his home.

Case XIV.—Madame K., æt. 57, June 12th, 1878. R., S. $\frac{6}{18}$; with $\frac{1}{40}$, S. $\frac{6}{9}$ (close by), F. free, T. increased, imperfect glaucomatous excavation. L., S. $\frac{6}{36}$ without correction, peripheral vision defective downward, T. increased and of the same degree as in R. Excavation. An upward iridectomy had been made on this (L.) eye three months before at another clinique. The coloboma lies directly upward. Cornea appears diffusely clouded on lateral illumination; downward there is a small, deep-seated, half-moon-shaped cloudiness, probably caused by the point of the knife.

June 13th, sclerotomy, R., upward with perfect success. June 18th, patient discharged, wound healed, no blood in anterior chamber, no cloudiness, T. distinctly lessened.

To sum up:

Case I.—Acute inflammatory glaucoma cured completely by Wecker's sclerotomy.

Case II.—Chronic inflammatory glaucoma cured completely by Wecker's sclerotomy.

Case III.—T. much diminished and almost normal in twenty days after Wecker's sclerotomy, in an eye blind from chronic inflammatory glaucoma.

Case IV.—In a hard left eye, blind from glaucoma simplex, T. is lessened more lastingly and more noticeably by a simple sclerotomy with a lance-knife than by a double (opposite) iridectomy in the R. E., which shows the beginnings of the disease—an extremely striking fact for all observers of this case.

Case V.—T. notably lessened by (lance) sclerotomy in an eye blind from glaucoma simplex.

Case VI.—T. of both globes in a case of glaucoma simplex reduced to even less than normal by (lance) sclerotomy. S. unchanged.

Case VII.—Eight and a half months after sclerotomy (lance) in glaucoma simplex, T. reduced to a physiological minimum; central vision wholly retained ($\frac{1}{3}$ in comparison with $\frac{2}{5}$ before the operation), in spite of the fact that at the time of the operation F. was defective, inward and downward, to within a few degrees from the point of fixation.

Case VIII.—Glaucoma simplex, sclerotomy (lance) in both eyes. R., where S. was $\frac{5}{200}$ only and eccentric, had phthisis corneæ, owing to a prolapse of iris. L., T., formerly very high, is normal nine months after operation, central vision retained, although somewhat less, in spite of the fact that before the operation F. reached only 5° upward and downward. The patient informs us that sixteen months after the operation his condition is unaltered.

Case IX.—Glaucoma simplex, T. reduced by (Wecker) sclerotomy, fifteen months after operation from T. +3, to T. +1 (?). S. still $\frac{10}{20}$ fully, although at time of operation there was extreme concentric contraction of F., even to 5° from point of fixation.

Case X.—Glaucoma simplex; R., S. =0, L., S. $=\frac{15}{30}$. (Wecker) sclerotomy. Fifteen months later, T. quite normal. L., S. $\frac{15}{20}$.

Case XI.—Glaucoma simplex, sclerotomy (Wecker) R.: twenty hours later, prolapse of iris (should have been excised, as advised at another place), and healing without decided injury. Perfect success of sclerotomy in reducing T., L.

CASE XII.—T. *not* diminished in glaucoma simplex after a *double* sclerotomy (Wecker) in both eyes. S. unchanged, peripheral amblyopia seems to advance.

CASE XIII.—Glaucoma simplex, T. lessened after sclerotomy (Wecker). Old cloudiness of cornea unaltered five days later.

CASE XIV.—Glaucoma simplex, sclerotomy in an eye fully capable of work, T. lessened.

II. SECONDARY GLAUCOMA.

In order to throw light on iridectomy and sclerotomy in secondary glaucoma, these cases are adjoined.

CASE XIV.—Caroline Hauser, æt. 54, April 22d, 1876. L., ectatic leucoma adherens. T. +3, S. =0. Sclerotomy (Wecker) does not lessen T.

CASE XV.—Johann Hass, æt. 20, Oct. 14th, 1874. R., ectatic leucoma adherens. T. +2. S. =0. Oct. 5th, iridectomy downward, excision of a large piece of iris from the pupillary to the ciliary edge, Oct. 21st, T. much less than normal. Oct. 24th, T. increasing, but still sub-normal.

Nov. 6th, T. increased above normal. Nov. 17th, sclerotomy (Wecker) upwards. Nov. 19th, T. does not lessen.

Dec. 18th, iridectomy upwards, the iris falls from its insertion. I make an incision with Graefe's knife in the lower scleral border and remove the whole iris. Dec. 22d, T. indeed somewhat less than before the last operation, but still above normal; ectatic spot not lessened. Fundus oculi visible, deep total excavation, opacities in vitreous. That is to say, two iridectomies, two sclerotomies, and removal of the whole iris without benefit.*

CASE XVI.—Anna Neuhauser, æt. 9, July 20th, 1875. R., partial staphyloma of cornea, T. extremely high, S. $\frac{5}{100}$. Sclerotomy (lance) downward, under narcosis. July 24th, T. lessened. Staphyloma smaller. When the anterior chamber is restored, after a few days, the staphyloma disappears entirely, but July 28th T. increases and the staphyloma bulges forward again.

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* As to the wholly untrustworthy action of iridectomy in secondary glaucoma after leucoma adherens, see Graefe, Arch., XV., 3, 135. I, too, could cite numerous cases to show its complete inefficiency, even when we make a second iridectomy opposite the first, and then supplement both by a third.

Aug. 21st, iridectomy upward.

Sept. 4th, result wholly negative, T. and staphyloma as before. Iridectomy was regular.

Case XVII.—Josef Weitlauer, æt. 63, April 21st, 1876. L., secondary glaucoma after traumatic dislocation of lens. When the eye moves, the opaque lens can be seen moving in the bottom of the eye. T. + 2 to + 3. S. = 0. Cornea slightly hazy all over. Pupil dilated *ad maximum.*

April 23d, (Wecker) sclerotomy. April 26th, cornea remarkably cleared. T. not disappeared.

May 8th, T. has decreased very perceptibly within forty-eight hours. May 25th, T. + 1.

Finally, let me cite a case of congenital hydrophthalmus. The action of sclerotomy is here of much the higher value, since iridectomy is an extremely dangerous operation in buphthalmus, but, as we have before seen, we cannot answer the indications to make the section of the sclera and excision of the iris of the same value as in the undistended eye.

Case XVIII.(*)—Luigi Bernardi, æt. 6, from St. Ulrich in Gröden, was born with R. E. larger than L. He was never sick and his mental development is good. When 2 years old, he struck his head against a wall. After that, L. became red from time to time, and began to enlarge, although, as his father says, this eye was formerly of normal appearance and, in so far as he could judge, had perfect vision. For one year past, a gray membrane (complete cataract) has been noticed L., but with R. he could see well until 4 or 5 days ago (March, 1877). Up to this time he could work with knife, hammer and auger, and drive nails, etc. The blindness was noticed one day at meal time, when he could not see anything, and ran against the furniture in the room. Three days before the blindness, he complained of supraorbital pains, tears flowed from R., but without any remarkable redness either then or now.

R., T. + 3, globe remarkably large and extremely prominent. Cornea cloudy in stripes, limbus corneæ broadened, diameter of base of cornea 18 mm., radius of cornea about 9.5 mm.; anterior chamber very deep; iris brown, fibres distinct, tremulous; pupil wide, black, mobility imperceptible. Lens and vitreous perfectly transparent, with mirror m. $\frac{1}{14}$. Papilla deeply excavated, no pain, no perception of light.

L., T. +1 to +2. Globe smaller, less prominent than R.; cornea clear, diameter of base of cornea 15 mm.; anterior chamber deep; iris changed in tint and fibres, adherent to anterior capsule; cataract.

Sclerotomy downward in both eyes. May 9th, Dr. Plenk, who had been present as assistant, writes:

"The boy with buphthalmus was discharged, T. very favorable in both eyes, somewhat sub-normal. Blood (there had been frequent secondary hemorrhages into the anterior chamber) absorbed from anterior chamber L., R., vision improved, not exactly determinable, *but the boy counts fingers at about* 10′, *pupil perfectly round, reacts promptly.*

The results of sclerotomy are, no doubt, noteworthy. Leaving out of consideration that it acts just the same as iridectomy, it has never yet caused a deterioration of vision as in the cases of iridectomy cited previously.

Cases VII., VIII., and IX. are especially noteworthy in this respect, as in VII. and VIII., the defect in the field of vision moved in, at spots, to within 5°, and even less of the point of fixation, while in IX., there was an extremely concentric contraction of F. Every unprejudiced observer of the results of iridectomy and sclerotomy here communicated will be obliged to confess that certain ill results of iridectomy do not seem to attach themselves to sclerotomy. No one will earnestly reproach sclerotomy, because once, with the lance section and without eserin, there was a supplementary prolapse of iris and purulent keratitis. This will be avoidable by a correct procedure before, during, and after the operation. Luckily in this eye there was very slight vision to begin with. And how many victims has not iridectomy offered up in acute glaucoma (that most favorable form of glaucoma) by wounding the lens, leaving entirely out of consideration those cases in which suppuration of the eye ensued upon a perfect iridectomy!

I have drawn attention to the extreme contraction of F. in VII., VIII., IX. for the following reasons: The history of the account of diminution of sight immediately after iridectomy (in spite of normal course of healing) is this; v. Graefe (his Archiv, VIII., 3, 307, 1862) says: "In a case of glaucoma simplex of myopes, where F. was already cut off close to the point of fixation (I dare not be silent on this), there came on, after the operation, a decrease of central vision from No. 11 to No. 15, which was compensated for but very gradually and never fully." He cites this case, to be sure, "not to weaken the indications for the operation," but, on the contrary, "to incite us not to delay till the point of fixation is threatened, and *when, probably, any sort of interference in the circulatory relations may let fall the sword already hanging over it.*"

In 1869 (Arch., XV., 3, 182), Graefe repeated his accounts of the hazardous sequences of iridectomy when the defect in F. approaches the point of fixation, *but again only for glaucoma in myopic eyes.* "I have seen two patients, who still fixed centrally, lose their vision permanently after iridectomy without the ophthalmoscope showing any reasons therefor."

At the Heidelberg Ophthalmological Society, in 1869,* Berlin mentioned five cases of simple chronic glaucoma where, directly after a regular iridectomy and without any hemorrhage at the time, he had noticed an acute diminution of vision. In one of these cases, on which Mooren had operated, No. 3 was read before and barely No. 20 after the operation. At the same session, I added that I knew of a number of cases of chronic glaucoma in which, after iridectomy, there had been a terrible decrease without any discoverable reason. At that time, I had no cases of glaucoma in myopia, nor in eyes whose central vision had been lost after the operation.

Schnabel also knows about the "frightful" alteration in vision after iridectomy. He explains it "chiefly" by the enlargement of the normal pupil by the coloboma (these ARCHIVES). Schweigger, too knows of these ill and now often mentioned results. He says (Volkmann's Vorträge, 124, p. 1039): "In the cases that I have seen, central vision seemed threatened greatly, long before the operation." The defect in F. extended already close up to the point of fixation, and afterwards crossed it, so that central vision was lost, and only eccentric vision remained. But Schweigger does not mention these as *myopic* eyes. I mention this, because Hirschberg (l. c., 176, 191), communicating a bad result of iridectomy in glaucoma simplex of a myope, appeals to Schweigger's confirmation of v. Graefe's assertion as to such cases. But this is not wholly apt, and just as little can I assent when Hirschberg says, "Mauthner's single case seems to belong here also," because, in those two cases of mine (Wiener Med. Wochenschrift) to which Hirschberg refers, there was no mention made of previously existing myopia. The sad results of iridectomy herein communicated had nothing to do with myopic eyes. The ill results seem most to be feared in glaucoma *simplex* with *extreme* contraction of F., but they are met with in cloudiness of media (Case III., R.) and with a moderately wide F. (Case VII., L.); but in this latter case there ensued at last a detachment of the retina, which, however, does not alter our suspicions as to iridectomy. I have never yet seen such ill results after sclerotomy.

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* Zehender's Klin. Mon. für Augen., 1869, 402.

In case we do not make up our minds altogether to replace iridectomy by sclerotomy, I should like to point out those cases where, to me, iridectomy seems no longer allowable, and in which it should unconditionally be replaced by sclerotomy:

1st, in the so-called prodromal stages of glaucoma; *i. e.*, where between the separate inflammatory attacks the function of the eye remains wholly intact.

2d, in glaucoma simplex, where central and peripheral vision are still almost normal.

3d, in chronic glaucoma when the defect in F. has drawn extremely near to the point of fixation, even if from one side only.

4th, in congenital hydrophthalmus.

In 1 and 2, the coloboma may do great damage to vision, and in 3, "the sword of Damocles may fall," and in 4 the eye may be destroyed by the operation (iridectomy).

In certain forms of secondary glaucoma, *e. g.*, in glaucoma after luxation of the lens, and after choroiditis serosa, as also in glaucoma hæmorrhagicum and finally in glaucoma absolutum, the conditional supporters of sclerotomy will, probably, prefer to try it, rather than iridectomy. But in exceptional cases, for instance, where in acute glaucoma the anterior chamber is especially shallow, and where a sclerotomy appears almost impossible of execution, its most absolute supporters will not perhaps endanger the eye, just to—save a principle. But Case No. 1 proves not only that sclerotomy is practicable in glaucoma acutum, but that it is of most perfect effect.

My views as to the signification of the symptoms of glaucoma, as also of the theories of glaucoma, will follow in the next volume of these ARCHIVES.

CONTRIBUTIONS TO THE KNOWLEDGE OF GLAUCOMA.

BY PROF. DR. J. SCHNABEL, OF INNSBRUCK.

Translated by DR. R. O. BORN, of New York.

(Continued from page 38 of this volume.)

(See Plate IV.)

10. *George Malysch*, 47 years of age, became blind in his left eye after an injury, a piece of wood having struck his eye. About six weeks later, the sight of the right eye began to be dim. In the course of six months, the vision of the right eye was reduced to quantitative perception of light, and only then the patient presented himself, on October 24th, 1875, in *v. Jaeger's* clinic. The left bulbus was considerably diminished in size, soft, not painful. The right showed an advanced irido-choroiditis. On October 26th, the left bulbus was enucleated.

Of the results of the miscroscopical examination I shall only point out that the iris and ciliary body were densely infiltrated with pus, the latter dislocated toward the axis of the eye, and as well as the iris considerably approached to the cornea, without attachment, however, of the walls of the chamber. The anterior layers of the iris were pervaded by an uncommonly light brown-yellow pigment, which was partly free in granules or round clusters, and partly had entered the numerous cells. A quite similar condition was found in the tissue of the scleral channel, between the lamellæ reaching from the margin of Descemet's membrane to the ciliary muscle.

11. *Franz Brödler*, 39 years old, was admitted to *v. Jaeger's* clinic on July 27th, 1873, for iridocyclitis oc. sin. Four years ago, the left eye had been injured (probably by a fragment of stone), and since then had been repeatedly attacked by severe inflammations. Since the patient began to complain of impaired vision in the right eye, the left globe

was enucleated on August 12th. The tension of the globe was then very much diminished, the sight reduced to quantitative perception of light. The form of the globe was normal. The cornea rather opaque; the chamber very shallow and contained much pus.

The microscopical examination showed an intense infiltration of the corpus ciliare and the iris, between the lamellæ; from these the infiltration extends in the iris angle up to Descemet's membrane, and fills the scleral channel. The area of the latter presents a well-defined infiltration in sclerocornea, which is otherwise perfectly free from inflammatory products.

From the related facts we see that the infiltration of the alveolar tissue of *Fontana's* space is of very frequent occurrence in inflammatory diseases of the anterior segments of the eye. The sources of this infiltration are the same as those of hypopyon, and from the presence of pus-cells in the cavities of *Fontana's* space we can no more assume a purulent proliferation starting from the trabecles, than conclude that those parts of the anterior chamber which are covered by the hypopyon have produced the pus. The cavities are the reservoir, not the place of formation of the pus-corpuscles, which naturally in their migrations move and accumulate where they find the least resistance. The depression of the slerocornea between the margin of Descemet's membrane and the origin of the ciliary muscle is filled with layers of perforated membranes. The openings of the most posterior of these sieves are not covered toward the anterior chamber, and hence the aqueous humor constantly washes the trabecles of *Fontana's* space. It is, therefore, not astonishing that the pathological fluids of the anterior chamber also fill the cavities of *Fontana's* space.

But this is not the only way in which blood and pus enter *Fontana's* spaces, and I believe it is not even the usual way. *Fontana's* space can be densely infiltrated without any accumulation of pus in the chamber. When the origin of the iris and that part of the ciliary muscle adjoining the anterior chamber have been infiltrated, the mass will move between the lamellæ, toward the margin of Descemet's membrane and the tissue of the scleral channel. That this is the case is shown especially by the arrangement of the pus or blood-corpuscles, but also by the perfect concordance of the manner and quality of the infiltration of iris and ciliary body on the one hand, and of *Fontana's* space on the other. I could never observe a suppuration of the tissue of *Fontana's* space. Also the limitation of the infiltration to the upper layers of the scleral channel, whilst its walls remain perfectly free, argues against an inflammation of the tissue of *Fontana's* space itself. Therefore, from the mere presence of the infiltration we can by no means conclude that there is an inflammation in *Fontana's* space. The possibility of an inflammation of that tissue can certainly not be disputed, but it appears not very probable to me that such an inflammation should occur frequently. The character of this tissue does not at all lead to that supposition. *Knies* thinks the importance of that place for the nutrition of the interior of the eye, and especially for the vitreous, allows us to suppose that an independent inflammation in the surroundings of *Schlemm's* canal may occur. But the physiological importance alone of any part of the eye could only entitle us to such a supposition if we could demonstrate that the function of an organ is frequently the cause of inflammation.

In all the cases in which the angle of the anterior chamber was obliterated, a keratitis suppurativa with subsequent perforation had existed. Before the chamber had been closed again, the iris had remained in perfect contact with the cornea for a different length of time, and after cicatrization the iris was by the anterior synechia kept in an abnormal approximation to the cornea.

But I have observed the obliteration of the angle of the anterior chamber also in cases in which the anterior chamber has been opened by a suppurative keratitis without the formation of an anterior synechia, and also in cases where the iris was impacted in corneal wounds, after an extraction or iridectomy.

12. *Magdalena Schmiegelhofer*, 6 years old, was admitted to *v. Jaeger's* clinic on October 1st, 1873, for central leucoma of both eyes. The corneal cicatrices were opaque, of a milky white color, round, and

covered the pupils entirely. The iris was in the normal plane. On October 15th, 1873, an inward iridectomy was made in the right eye. Since the effect of the operation was not sufficient, on November 19th an iridectomy of both eyes was performed. On November 20th, the patient died.

The microscopical examination yielded results so similar in both eyes that I do not describe them separately. The periphery of the anterior chamber did not show the same condition in all the meridional sections. In many it hardly deviated from the normal; the only striking feature was, that the lamellæ which covered the scleral channels were *usually widely* separated from each other and projected markedly into the anterior chamber. In many sections, the angle of the anterior chamber had entirely disappeared, the iris being agglutinated to the cornea nearly up to the margin of Descemet's membrane. The tissue of the corresponding piece of iris was very much loosened, as if its anterior surface had been lifted up and retained, while the posterior layer had not essentially changed its position. The angle of the anterior chamber was thus filled with a loose tissue, consisting of loose iris-tissue, and of bands of the cavernous tissue which had been separated from the main mass and become connected with the iris. In other sections, the origin of the iris formed an arch with its convexity forwards, joining closely the lateral and anterior walls of the angle of the anterior chamber. *Schlemm's* canal was everywhere open and empty. None of the parts which concur in the formation of the periphery of the chamber was infiltrated.

The stump of iris which had remained in the right eye after the first iridectomy had healed into the inner wound, making thereby the attachments between periphery of iris and ligamentum pectinatum the more intimate.

13. *Johann Hauenstein*, 84 years old. I enucleated his right eye twenty-one hours after death. On this eye a perfectly successful *Gräfe's* extraction had been performed, of the history of which unfortunately I could learn nothing. The stump of iris was attached to the inner wound, but did not project into the canal of the wound itself. The piece of iris between the inner wound and the origin of the iris (about

1.5 mm. long) was in most of the sections nearly in its whole extent attached to the ligamentum pectinatum and Descemet's membrane; in others it was agglutinated only to the ligamentum pectinatum on one side, and to Descemet's membrane, close to the inner wound, on the other side, and between them existed a free bridge of iris.

Hardly any further proof needs to be adduced to assert that the apposition of iris and cornea of some duration is the essential cause for the obliteration of the angle of the anterior chamber. It will, therefore, be least intense where we had only perforation of the cornea without impaction of iris (cases 4 and 12); it will be more developed in cases of anterior synechia and flat corneal cicatrix (cases 1 *a*, 2 and 3); it will reach the highest degree in bulging leucoma adhærens, in cicatricial staphyloma (cases 16, 5 and 6); it will involve the whole periphery of the chamber where the impaction of iris is circular (cases 1, 2, 3, 5 and 6); it will be partial if only a segment of iris had healed into the wound (cases 4 and 13). The attachment of the walls of the chamber must take place more quickly and more easily, and must be more intimate, where the iris is attached to the ligamentum pectinatum than where the iris adheres to Descemet's membrane; for the latter is smooth, but the ligamentum pectinatum has numerous gaps and depressions, and offers thus a greater surface for contact and brings about a closer *connection.*

The condition of the origin of the iris and of the tissue of *Fontana's* space is the result of the traction to which the former, and of the compression to which the latter had been subjected; the anatomical condition in the parts which are agglutinated to each other points clearly to its cause. The attachment of the iris to the ligamentum pectinatum is caused by a disease of the endothelial sheaths of these tissues, but I cannot decide whether this disease is only the consequence of abnormal contact, or whether, as in kerato-iritis, it is one of the effects of this process. We can suppose, however, that the pus-cells which are accumulated between the meshes of the ligamentum pectinatum and on the surface of the iris favor the agglutination. But it is certain that it is not produced only by the infiltration of the two surfaces (see case 7). Collections of great quantities of pus in the angle of the anterior chamber prevent the obliteration by hindering the direct contact of the walls of the anterior chamber.

5.

The last of the questions set forth in the beginning is settled by answering the first four. The pathologial changes in the periphery of the anterior chamber, with which we are occupied, do not necessarily present the peculiar clinical picture of the glaucomatous process. Which functional disturbances of the eye are caused by the obliteration of the angle of the anterior chamber I cannot yet tell, but I am convinced that it frequently exists without being clinically observed. The existence of corneal cicatrices into which the iris has healed do not endanger the eye. The peril of increase of tension and of consecutive excavation of the optic disc occurs only when the cicatrix begins to bulge. The obliteration of the angle of the anterior chamber alone is harmless; the traction of the origin of the iris and the stretching of the sclerocorneal margin cause the increase of tension.

Among the cases described by *Knies* is one in which, notwithstanding the good result of the iridectomy, the attachment had remained also in the extent of the coloboma. The glaucomatous process, therefore, continued in its anatomical condition after the operation without being clinically observed. I must confess that a doctrine which leads to such a view as to the curative effects of the iridectomy appears to me wholly inadmissible, and I reserve further remarks for the second part of the paper, which will contain the results of the anatomical examination of glaucomatous eyes.

I should like yet to add here my experiences about the value of that method of operation for glaucoma which constitutes only the first act of the iridectomy. I have purposely not used the name sclerotomy, because this name has also been given to operations which differ from the ordinary operation for glaucoma in more than the mere omission of the excision of iris. When *Bader* for the cure of glaucoma makes a scleral wound which produces a constant communication between the anterior chamber and the subconjunctival space, and when he succeeds in this way,* there follows only that we can cure the glaucoma by other ways than iridectomy, but it does not follow that in iridectomy the effect is only the consequence of the scleral wound. To solve by experiments the question of the value of the two acts which now constitute the iridectomy in glaucoma, it is necessary to perform the first step separately and exactly in the same manner as we do in cases in which the excision of iris is intended.

In the following, I shall relate the results of my experiments made in that direction in *Jaeger's* clinic. For this purpose I chose almost exclusively cases of inflammatory glaucoma, because the influence of the operation upon the pain, the injection, the opacities of the media, give a more certain basis for our judgment than the result as to the anomalies of tension and the vision. This is especially important if we cannot continue our observation for a long period of time.

1. *Anna Neisser*, 52 years old, glaucoma inflammatorium chronicum oc. utr. Both eyeballs were exceedingly hard ; the cornea streaked and so opaque that it became impossible to obtain rays of light from the fundus ; the pupils large, rigid, round ; the anterior chamber of normal depth. In the right, uncertain perception of light, in the left amaurosis.

March 29th, 1876.—Right, iridectomy inward. Left, sclerotomy.

March 30th.—Both chambers refilled.

March 31st.—Both corneæ with oblique illumination smooth and shining.

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* *Bader*, Sclerotomy versus Iridectomy, Ophth. Hosp. Rep., VIII., 3, p. 430.

Sclerotomy.	*Iridectomy.*
April 1st.—Cornea perfectly transparent, tension below normal and less than in the eye on which iridectomy was made.	The chamber still filled with blood. Tension below normal.
April 4th.—Tension in both normal. Vitreous perfectly clear. Large extravasation in retina.	The absorption of the blood goes on. Details of fundus indistinctly visible.
April 6th.—Tension in both normal.	
April 8th.—The tension has increased decidedly above the normal.	Tension considerably less than in the left eye, *about* normal.
April 10th.—The ectasia of the region of the wound has somewhat decreased. Tension higher that normal.	Tension normal.
April 11th.—Tension greater than normal.	Tension below normal.
April 12th.—Tension somewhat diminished, but still abnormally higher.	Pain of short duration. Injection. Tension normal.
April 13th.—	The ophthalmoscope showed today large extravasations of blood in the retina.
April 19th.—The slight ectasia and tension somewhat above the normal have remained up to this day.	Tension has remained normal. Patient discharged.

Opacity of the media and glaucomatous pain did not occur again as long as the patient was under observation.

2. *Jacob Krauer*, 57 years old. Glaucoma inflammatorium chronicum oc. utr. The left has been amaurotic for one year, the right for three months. In the left, beginning glaucomatous degeneration. On May 4th, 1876, I found in the right eye the cornea *so opaque* that I could not see the fundus of the eye. At 3 P.M., the cornea had cleared up and I could perceive the details of the fundus. The pupil was round, rigid, twice as large as normal; the iris looked bright, the lens clear, and the image of its anterior capsule in the daylight strikingly greenish; vitreous clear, the choroid dotted; the optic nerve slightly excavated without white ring. Tension moderately increased.

May 6th.—Sclerotomy in the right.

May 8th.—The eye looks well. The cornea clear. Tension below normal.

May 10th.—The same. The pupillary margin somewhat sinuous in the direction of the meridian of the wound. Corresponding to the wound a slight elevation of the conjunctiva. Very slight hyphæma. Fundus of the eye nicely visible; in the region of the macula lutea some circular dark-red extravasations of $\frac{1}{3}$ to $\frac{1}{2}$ of the diameter of the papilla.

May 12th.—Condition unchanged, except a very slight increase of the hyphæma.

May 22d.—Tension higher than normal, but less than in the left.

May 24th.—Tension as on the 22d. The cornea continues transparent. The conjunctiva above the wound somewhat elevated.

May 26th.—Condition unchanged.

May 27th.—With very intense pains in the eye and head, and without a further increase of the tension, the characteristic glaucomatous opacity of the cornea reappeared. Ciliary injection.

May 30th.—The patient leaves the hospital. The bright lustre of the eye after the sclerotomy was lost again, corneal opacity and ciliary injection have somewhat diminished, but still continue; the pain has ceased. The tension is less than before the sclerotomy, but higher than normal.

3. *Maria Halenta*, 54 years old. Glaucoma simplex oc. sin., glaucoma inflammatorium acutum oc. d. The patient had perfectly normal eyes until April 4th, 1876. On that day, shortly after a very severe emotion, she grew blind in the right eye, with extremely severe pain in the corresponding half of the forehead, temple, and occiput. On April 5th, with the right eye the patient could still see fingers in the lower outer quadrant, when they were held at the distance of a few inches; from April 6th, the affected eye has been entirely blind. May 19th, tension much increased. Cornea slightly dotted and so opaque that I could recognize the place of the pupil, but could observe no details. Patient states that the left eye does not see as well since the attack in the right. There has never been any pain in the eye, but a considerable obscuration of short duration is said to have occurred. On May 17th, while patient was on her way to Vienna, she was troubled by a very marked micropsia: "the children appeared as large as the dogs, the trees only a few inches high, and all the people were dwarfed." Passing over the bridge of the Danube, she believed the surface of the water to be very

near the level of the bridge, etc. The tension of the eye is very high. Sclera and cornea look normal; the anterior chamber perhaps flattened; the pupil a little wider than normal, reacting well, and black. S. $=\frac{20}{30}$. Visual field normal. Well-marked glaucomatous excavation. Left iridectomy, right sclerotomy. Immediately after the lance-shaped knife had been removed from the chamber of the right eye, the pupil was round, but a short time afterwards it became distorted. After the removal of the conjunctiva from the scleral wound, the iris showed itself in the lower portion of the wound. It was pushed back with the forceps, and then prolapsed at the other end of the wound. Having again been put in position, it remained in the chamber. Instillation of calabar.

L. Iridectomy.	*R. Sclerotomy.*
May 21st.—Wound normal, bulbus soft.	The pupillary margin is slightly sinuous toward the wound. Cornea shining.
May 23d.—Tension lower than in right.	Tension normal.
May 24th.—The same. Media clear. No hemorrhages in retina.	Media clear. Considerable hemorrhages in retina.
May 26th.—Tension normal.	Tension a little higher than normal.
July 10th.—Tension normal. Large, beautiful coloboma inwards. Cicatrix perfectly flat. Acuteness of vision without glass hardly $\frac{20}{100}$, with $+\frac{1}{20}$ hardly $\frac{20}{50}$, putting a diaphragm with a small hole in front, $\frac{20}{40}$.	Tension had always remained a little higher than in the left eye; but the difference of tension is so trifling that I would not call it pathological if I had not been able to compare it with the left eye. The media have remained perfectly clear. The pain has entirely passed away and the general indisposition which had been caused by this eye, the uneasiness, the want of sleep and appetite, have been wholly removed. The increased extravasations of blood have not yet entirely disappeared.

4. *Marcus Bledy*, 66 years of age. Glaucoma inflammatorium acutum

o. d., glaucoma simplex o. sin. States that the right eye grew blind six years ago with violent pain. The pain was only of short duration; the sight remained abolished. Fourteen days before patient entered the hospital, new attacks of pain appeared in the blind eye. On July 7th, 1876, it showed the following condition: Tension very high; conjunctiva injected; cornea dotted and opaque, sensitive to the touch; chamber normal; pupil of medium size, rigid, circular. The sight of the left eye has been failing for years, but pain was never noticed. The acuteness of sight is said to have often greatly fluctuated even during the time of one day. Every day patient sees well immediately after awakening; two to three hours later, suddenly an obscuration appears which is often so great that he cannot find his way. "It is as if somebody would open an umbrella in front of my eyes." The patient has found a means to make his eye clear up again. As soon as the obscuration appears he lies down and sleeps a little. On awakening, the eye is clear.* If he does not succeed in falling asleep, and is only lying quietly with his eyes closed, the obscuration remains. On July 7th, I found the tension much increased; no injection; the cornea dotted, dull, sensitive to the touch; the chamber shallower than in the right eye; the pupil of medium size, circular, rigid. The fundus cannot be seen. Counts fingers at 7′. Concentric limitation of visual field. On July 8th, in the morning, I found the tension perfectly normal; the cornea shining and transparent; the pupil clear, black, normally wide, reacting slowly; the glaucomatous habitus of the eye had entirely disappeared. Pronounced glaucomatous excavation; inwards from the papilla some small yellow choroidal spots. S. $=\frac{20}{100}$.

July 8th.—Left, iridectomy inwards; right, sclerotomy. In the left, the course of operation and healing was normal. In the right, in pushing the knife forward, the iris was caught and carried toward the pupil before it could be freed. No visible detachment at the ciliary margin was caused. A few hours after the operation, extremely severe pain. The wound had a good appearance. The cornea dotted in its lower half. The chamber filled with blood. Tension far above the normal. July 9th, in spite of ice-applications and injections of morphium, the pain still continues. It has its seat in the temple, and from there radiates to the teeth of the upper maxilla; "*there cannot be more dreadful pain.*" The eye shows the same condition as yesterday.

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* Quite analogous statements about the influence of sleep upon the vision I got some years ago from another patient with glaucoma simplex. He also had learned to get rid of the frequent obscurations by lying down and sleeping for a few minutes. I did not mind these statements at that time, but remembered them when I learned B.'s history.

July 11th.—To-day the pain is less. The chamber is filled with blood, tension very high.

July 16th.—Occasionally the pain appears again. The patient has been very much reduced by his sufferings. The wound has healed very well. The cornea dotted. On account of the blood in the anterior chamber, it is still impossible to see the iris. Tension higher than normal. The eyeball very sensitive to the touch. July 28th, I find a severe iritis; the pupil is occluded by loose exudations. August 22d, the irido-cyclitis caused by the sclerotomy continues. The tension is sometimes normal and even below the normal, then again increases to a pathological degree.

The pain shows only frequent intermissions, but still at times is very intense. The epithelium of the cornea loosened; the iris vascularized. The anterior chamber contains fluid blood. Patient would not agree to have his eye enucleated, and therefore an iridectomy upwards was performed on September 25th. A large coloboma was made. The tension became normal by this operation, but the sufferings of the patient were not materially diminished, since the inflammatory symptoms continued. Moreover, the acuteness of sight of the left eye began to fluctuate considerably, but without any glaucomatous symptoms; and now, finally, the patient consented to the enucleation, which was made on October 18th. The results of the examination I shall report in another part of the paper.

5. *Maria Trausner*, 64 years old. Glaucoma inflammatorium oc. utr. In June, 1876, she suddenly lost the sight of her left eye entirely and forever with fearful pains in the corresponding half of the head. After a duration of three weeks, the pains abated and occurred only now and then in short attacks. Three weeks after the disease had begun in the left eye, the sight of the right eye began to fail under similar conditions. On July 24th, I found amaurosis in the left; with the right she counted fingers at 12′. In both a diffuse ciliary injection, increased secretion of tears, hyperæmia of conjunctiva; the corneæ were dotted, the anterior chambers shallow, the pupils circular, wide, rigid, grayish-green. The tension in both very high; from the fundus of the eye comes only an indistinct grayish-red reflex.

On July 24th, in the left eye paracentesis of the anterior chamber was made in the corneal margin with the same instrument that *v. Jaeger* uses to obtain aqueous humor.* Immediately after the puncture, the pupil of the other eye also appeared clearer, and at the same time I could see the corneal opacity more distinctly. Before the puncture it was impossible to see the papilla; but now, after the aqueous humor had escaped, I succeeded, although the patient was very restless. The collected fluid of the chamber was unfortunately soiled by some blood ; the microscopical examination showed (apart from the elements of the blood) no other solid ingredients than molecules of pigment and small clusters derived from the uvea of the iris.

On July 25th, 17 hours after the puncture, I found the eye free from pain, the chamber restored, the cornea opaque as before the operation. The tension again very high. The only change produced by the operation was a dilatation of the pupil. On July 25th, the same operation, as yesterday in the left, was now made in the right eye. The collected fluid was as black as a diluted solution of India ink. The microscope demonstrated the admixture of uveal pigment as the cause of the discoloration. No products of inflammation were found. But for a trifling quantitative difference, the conditions of the cornea, pupil, and fundus, which were ascertained immediately before and after the operation with oblique light and ophthalmoscope, were the same as yesterday in the left eye. On July 26th, 24 hours after the operation, the eye showed the same condition as before. Therefore, the influence of the incision with the knife in the cornea upon the opacity of the media and the tension was nil. On July 28th, a sclerotomy was performed on the left, an iridectomy on the right eye. Both operations had the same effect on the glaucomatous symptoms. On October 17th, when I saw the patient the last time, the condition was still unchanged and the same as shortly after the operation. Both eyes had normal tension, and the corneæ were shining and transparent. In this case the effect of the sclerotomy was perfectly equal to that of a successful iridectomy.

6. *Naphthali Eichhorn*, 46 years old. Glaucoma simplex oc. utr. The impairment of sight is said to have begun in the right eye ten years ago, in the left about one year ago. The eyes were never red or painful; sometimes the patient feels an uneasiness in his forehead, a roaring in his head ; as soon as he becomes excited, his sight decreases ; after

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* Its description and picture are found in *v. Jaeger:* Ueber die Einstellungen des dioptischen Apparates, pages 136 and 137.

sleep it is better. In the external parts of the eye are only slight anomalies. The scleræ are of a somewhat dirty color; the episcleral vessels are small. The corneæ are sensitive to the touch, ordinarily smooth, shining, and only at times a little misty and dull; the anterior chambers somewhat shallower than normal; the pupils a little wider than normal and reacting slowly. Deep excavations. Right, movements of hand seen at 6′; the outlines of the visual field cannot be determined. Left, S. fluctuates between $\frac{20}{40}$ and $\frac{20}{50}$; the visual field is not contracted; only when the illumination is very week, there is some uncertainty in the extreme periphery. The tension in both abnormally high. November 27th, an iridectomy was made in the left, sclerotomy in right eye. December 23d, the tension became reduced in both eyes after the operation, but in the eye in which sclerotomy had been done, it remained always higher than in the other without being decidedly pathological. But since yesterday, however, the tension of the former is decidedly glaucomatous, while that of the latter remains unchanged and normal. The wound is closed in both eyes by a slightly elevated transparent intercalated substance. The iris in the eye with iridectomy has healed into both corners of the wound. In the eye with sclerotomy the surface of the iris in the region of the inner wound is drawn toward the cornea; the pupil of this eye has remained circular and movable. Yesterday the patient wrote a letter, and after that noticed a high tension in the sclerotomized eye, but no injury to the other eye arose from this effort. Left, S. $\frac{20}{70}$, not improved by glasses or stenopæic slit. Right, S. as before the operation, but the patient thinks the visual field is somewhat enlarged. December 30th, the tension in the sclerotomized eye continually much increased. Also now and then a slight corneal opacity appears again. Left, S. $\frac{20}{50}$ through a diaphragm with a fine hole; everything is much blacker and clearer; but of the test types XL, only F is recognized. A solution of eserine of only one per cent was instilled, and its influence upon the tension was striking; the eye became softer than the iridectomized eye. The reduction of tension continued till January 6th, 1877, during which period one drop daily was put into the eye. On January 6th, in spite of the eserine, the tension rose above the normal and on January 8th, it was decidedly glaucomatous. Now we put the eserine in twice a day; every time after the instillation of the drug the tension was distinctly diminished. This, however, was usually only of a short duration. In the same proportion as the influence of the eserine upon the anomalous tension decreased and finally became uncertain, the duration also of the contraction of the pupil was lessened after frequently repeated instillations. By experiments on other individuals it was shown that the fault was not to be ascribed to a change in the solution of the eserine. On January 17th, the patient left the hospital, since he did not consent to an iridectomy which was proposed. He returned, however, soon because of pain in the sclerotomized eye. The tension was abnormally high and also opacity of the cornea appeared again periodically. The iridectomy made on January 23d, had a perfect and lasting success.

Only in one case (5), the result of the sclerotomy was equal to that of a successful iridectomy. But this is perfectly sufficient to demonstrate that it is not necessary to interfere with the vascular system of the uveal tract to diminish the increased tension, and to make the symptoms of the glaucomatous ophthalmia disappear. It is an important as well as striking fact that a simple incision with the lance-shaped knife suffices to cure thoroughly long-continued and severe glaucomatous symptoms which are known to have intermissions, but are not cured when left alone. Nothing is more apt to shake the opinion that glaucomatous ophthalmia is an inflammation of the uveal tract. It would contradict all our experiences about inflammation in general and choroiditis in special, if we should suppose that such a process which has lasted for some length of time, and has developed to a great intensity, could immediately be interrupted by a therapeutical measure, particularly one not always directly affecting the domain of the uveal tract, and be so perfectly cured that even the products of inflammation disappear without a trace. The cure of glaucomatous ophthalmia by a simple incision with the lance-shaped knife, is incompatible with the supposition that it is the result of an inflammation, no matter whether we look upon it as a complication of the increased tension or as its consequence. For, even in sclerotomy we would, from the condition of the cicatrix, explain the diminution of the increased tension; the disappearance of the complicating inflammation would remain inexplicable, and likewise we would not understand why, after the removal of the cause, *i. e.*, the mechanical obstructions, also the inflammation should disappear with such a certainty, speed, and completeness.

Sclerotomy furthermore affords us much important information about the seat and nature of the opacity found in the media. *Knies* says he did not by the anatomical examinations come to a definite conclusion about the correctness of my statement, that in glaucoma the vitreous humor was not hazy. In regard to this, I shall remark that in my statements I denied the existence of an opacity of the vitreous which could be shown by the ophthalmoscope. The supposition of the diffuse opacity of the vitreous was based only upon ophthalmoscopical examinations, and in the same way I came to the conclusion that it was generally absent. Anatomy cannot furnish us with the knowledge which we require. I will here point out that the distinctness of the lens-images decides this question. In all the cases in which glaucomatous opacity of the media exists we find a proportionate indistinctness of the lens-images, and from that we can safely conclude that the impediment for the incident rays lies in front of the lens. The supposition that an inflammatory opacity of the vitreous, which in one case of glaucoma inflammatorium chronicum had existed for weeks, would after a sclerotomy disappear completely and immediately, seems to be in irreconcilable contradiction to all the experiences as to the course of opacity of the vitreous. It appears also, from the behavior of corneal opacities after sclerotomy, that we have not to deal with a keratitis. I have seen that very slight superficial (disciform) corneal opacities, which undoubtedly were caused by an inflammatory process, and which had externally the greatest similarity with glaucomatous opacities, were not all changed by the most beautifully made iridectomy. In two of the above-related cases (1 and 3) the result of the sclerotomy was almost as favorable as that of a regular iridectomy, and in two (2 and 6) a relapse followed the immediate improvement after operation. Also these four cases demonstrate that the incision in the regular iridectomy for glaucoma is not only a preparatory step for the really beneficial excision of iris, but that it possesses a true curative effect.

But the amount of the improvement after the incision is not uniform; sometimes it is equal to the total action of the iridectomy, sometimes it corresponds only to a greater or smaller part of it.

We cannot assume that the incision produces this effect only by the opening of the globe, for the experiments of incising the cornea in case 5 exerted no influence at all upon the glaucoma. The effect of the incision made beyond the margin of the transparent cornea can also not be explained by the quality of the cicatrix alone, for the nature of the wound and not the iridectomy influences the formation of the cicatrix. I am, however, perfectly convinced that no relapses would have occurred in cases 2 and 6, if the operation had not been restricted to sclerotomy, but extended to excision of iris. The reader, even without personal knowledge of the above-related cases, will certainly share this conviction, if he considers that we never find so great a proportion of only temporary successes in five regularly executed and *healed* iridectomies for glaucoma. If case 5 proves that the excision of iris is not absolutely required for the cure, cases 1, 2, 3 and 6 show that generally the excision is by no means superfluous; that it aids, completes, and secures the curative effects. Either step in the iridectomy, therefore, has some share in the cure of the glaucomatous process. The share belonging to the second step of the iridectomy can be attained by the first alone under certain conditions. In a regular iridectomy for glaucoma, the combined effects of the incision of the sclera and excision of the iris must, therefore, be due to an identical anatomical causation. Since the scleral incision may render the exision of the iris superfluous, the latter must necessarily act through a factor contained in the former. Consequently, the excision of iris cannot act by a diminution of the vascular area of the iris and its consequences; but, like sclerotomy, only by separating, respectively loosening, the connection between cornea and iris. For this reason the excision of the insertion of the iris is so very important.

I am not able to say how the sclerotomy, in the one case in which its result was perfectly equal to that of a regularly made iridectomy, differed from the execution of the sclerotomies followed by only partial effect. Continued experiments will still have to show how the sclerotomy shall be made in order to be satisfactorily substituted for iridectomy. The fear that by experiments with the sclerotomy we should endanger the welfare of our patients we can shake off already, for the experiences hitherto collected are sufficient to encourage the most scrupulous practitioner.

These experiments promise abundant results, both theoretically and practically. The possibilities which must be taken into consideration to explain the action of iridectomy in glaucoma would be considerably reduced if the operation for glaucoma itself could be simplified, and the probability of an error would be much lessened if we could omit one part of the operation which formerly appeared indispensable for the effect. But every advance in the operation of glaucoma must necessarily become important for the explanation of the nature of the disease, for if we learn to understand the changes produced by the operation, the condition also removed by those changes must become clearer.

But the solution of the question as to the value of sclerotomy possesses no less importance from a practical than a theoretical point of view. It is indeed important enough to replace a complicated procedure by a simple one, to keep a valuable part of the eye from mutilation, to preserve a circular, frequently movable, and sometimes even a narrow pupil. Of much greater weight yet is the prospect of better visual results. The influence of the coloboma upon the acuteness of vision is very considerable, and especially in cases of chronic glaucoma with an undilated pupil and relatively good sight it is quite extraordinary. In my article on "The Accompanying and Consecutive Diseases of Iritis" (Vol. V., pp. 153–187, of these ARCHIVES), I have on page 186 mentioned two cases in which, after a faultless operation in glaucoma simplex, the acuteness of sight was considerably diminished. Since then, I have found that the dilatation of a normally wide pupil by the coloboma explains this frightful diminution of the sight. The case of Marie Halenta offers a new instance, to which I add the following.

1. *Thekla Weigel*, 59 years old, has in both eyes a marked glaucomatous affection of the optic nerve, whilst both chambers have the normal depth, and the circular black pupils react with great readiness. Left: on June 1st, 1876, fingers counted at 20′, the visual field normal; right, S. $=\frac{20}{30}$, visual field perfectly free.

On July 2d, on both eyes an iridectomy inwards was made. Course of operation and healing were quite normal. On July 1st, in the right eye S. $\frac{20}{70}$; with $-\frac{1}{24}$ c., axis horizontal, S. $\frac{20}{50}$; by placing a diaphragm with a small hole before the eye, the patient was much delighted. Now she stated she could see clearly, while before "the mist was too thick," and S. was improved to $\frac{20}{40}-\frac{20}{30}$.

2. *Johann Benesch*, 65 years old, has in both eyes glaucomatous excavations, with almost total absence of alterations in the anterior part of the globe. On June 6th, 1875, S. in the left eye was $\frac{20}{50}$; in the right, $\frac{20}{40}$. No improvement by glasses. On June 8th, an upward iridectomy was made on both sides. Operations and healing processes quite smooth. On July 9th, 1875, I found in the left eye S. $=\frac{10}{70}$; with $-\frac{1}{16}$ c., axis vertical, S. $=\frac{10}{50}$, and by addition of a stenopæic apparatus, S. $=\frac{10}{40}$. In the right eye, without a glass, S. $=\frac{10}{40}$; with a stenopæic apparatus, S. $=\frac{10}{20}$.

APPENDIX.

A case of acute glaucoma produced by instillation of atropine.

Moritz P. was admitted to *Jäger's* wards, Feb., 1876, with glaucoma of the R. E. In the left, perfectly good eye, I instilled one drop of a solution of atropia of the strength of 1 : 2500 (*i. e.*, gr. $\frac{1}{5}$ ad ℥ i), for the sake of an ophthalmoscopic examination. Three hours later, moderate dilatation of pupil, nausea, pain in eye and head, loss of sight. During the night, restlessness and vomiting. T. increased. Forty-two hours after the instillation, the eye had a pronounced glaucomatous habitus, and S. reduced to $\frac{8}{200}$. Iridectomy.

Second Article.

(See Plate IV.)

Among the thirteen glaucomatous eyes of which I could make anatomical examinations, only two were found which did not present some anomaly of shape in the angle of the anterior chamber. These were the two eyes of a man with glaucoma simplex, which also otherwise showed none of those changes commonly found after the existence of increased tension during life (1 and 2).*

In all the other eyes in which the diagnosis of glaucoma had been made during life, or in which it had been found after death by unmistakable signs, the angle of the anterior chamber was obliterated by apposition and, with the exception of one case (4), also by agglutination of its walls. Generally, histological changes of the approximated or adherent walls of the anterior chamber were connected with this obliteration. Also in the cases of increased tension of the shortest duration which I could examine, the circular synechia of the ciliary zone of the iris extended up to the margin of Descemet's membrane, and did not exceed this limit at all or only very little, even in those cases in which the increase of tension had existed for many years. Corresponding to the duration and degree of the increased tension, the agglutination became firmer and the histological changes more extensive in the adherent zone of the iris. The agglutination was always uniform in the whole circumference of the angle, and the changes in the tissue of the attached parts (as far as they were not caused by processes which had only an accidental relation to the glaucomatous process) were homogeneous in all the parts of the same eye, and nearly of the same degree. From this we may conclude that the noxious condition which causes the abnormal position of the iris, affects at the same time and with the same intensity the *whole* periphery of the iris.

The agglutinated portion of iris was always thinned. In the extreme cases the atrophy was so great that the iris-tissue proper was found only at the margin of Descemet's membrane, and the iris seemed to originate here, as if cut in an oblique direction. Between this apparent origin and the ciliary body a shallow channel had been formed which was lined only by uveal pigment (10, 11, 12). The lamellæ which bridge over and fill the scleral channel were often considerably compressed, sometimes also atrophied, and had thus produced a slight depression at the site of the scleral channel, lined by iris. Schlemm's canal was mostly normal in form and size, and empty; sometimes its calibre was narrowed or perfectly invisible; in a case of very old glaucoma, however, I found it considerably enlarged (9). In some cases I found, besides the anomalies of position and texture, pus, blood, and pigment imbedded in and between the agglutinated walls of the chamber, exactly in the same manner as I described it in my first article, in eyes in which iritis, cyclitis, or keratitis had existed without showing this adhesion. In those cases, iritis, cyclitis, or keratitis were diagnosticated, clinically as well as anatomically, as independent complications of glaucoma. I have never seen a connecting substance which could have been supposed to be produced by the agglutinated walls of the chamber, or to have preceded and caused this adhesion; in this respect the formation of the synechia in glaucomatous eyes is perfectly in accordance with that formerly described in eyes without increased tension.

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* The numbers in brackets indicate the numbers of the examined eyes.

In eyes which have been lost by inflammatory processes in the uveal tract, without formation of pus and cicatrices in the external tunics, we frequently find, as is known, the most peripheral zone of iris in contact with the cornea. The consideration of this synechia has a double interest for us, since it appears in the course of an undoubtable inflammatory process, and is formed and persists in abnormally soft eyes. The simultaneous occurrence of a synechia, impeding the outflow of liquid, and of hypotony in eyes with atrophic alterations in the iris and ciliary body does not seem to be very difficult of explanation, since a diminution or suppression of the supply would not appear improbable. But if we look at it more closely, we find that a diminution of the vascular surface of the uveal tract is no more constantly combined with a diminished tension of the tunics of the eye than an increase of the vascular surface with a repletion of the eyeball. In fact, normal, increased, and diminished tension may result from the same size of the vascular surface, and hypertony is frequently combined with diminution, hypotony with increase of the vascular surface. Partial atrophy of the uveal vessels does, therefore, not explain the relaxation of the globe, and it seems nearly superfluous for me to refer to the conditions of eyes described hereafter, which show that a high degree of atrophy of the iris and ciliary muscle by inflammation, pressure, and traction is very well compatible with the continuance of a glaucomatous filling of the eyeball (11 and 12).

The peripheral synechia of the iris is formed at a period at which atrophy cannot be thought of, at which the form of the eyeball is normal, the disease capable of retrogression without leading to phthisis, and at which the existing inflammation manifests itself in a high degree of congestion and the migration of numerous cells into the tissues. In this stage of the process, the existence of diminished tension, and at the same time partial or complete abolition of the direct communication of the anterior chamber with *Fontana's* spaces by the adhesion of the iris and the ligamentum pectinatum, cannot readily be combined with the supposition that the synechia produces an increase of tension.

At the end of August, 1877, a woman, 40 years of age, came to my clinic with a double irido-choroiditis, and died seven weeks later from pneumonia complicating a chronic morbus Brightii. The disease of the eye had shown itself by diminution of sight, without any pain and redness, two years before her admission. The vision was constantly decreasing, and, when I saw the patient the first time, she could with her right eye count fingers only at a distance of 15 cm.; in the left she had S. $=\frac{1}{24}$ Schweigger. The iris showed the well-known symptoms of chronic iritis; the globe had a perfectly normal form, but the tension was below the normal during the whole time of observation. Forty-five hours after death I enucleated the eyes.

In both, the iris and corpus ciliare were densely infiltrated with pus-cells. Between the layers into which the tendon of the ciliary muscle inserts itself, and between those of the ligamentum pectinatum, from its insertion up to the margin of Descemet's membrane, were layers of pus-corpuscles. The tissue filling the scleral channel around *Schlemm's* canal was filled with pus-cells in the same manner, whilst sclera and cornea showed a normal appearance (cf. case 7 in the first article). In some places the sinus of the chamber was flattened, the iris being adherent to the lateral wall of the chamber, without touching its anterior walls; in most of the meridional sections, however, I found the anterior surface of the iris in contact, not only with the ligamentum pectinatum, but also with Descemet's membrane, to a varying extent. The radius of the agglutinated zone of iris was, therefore, different in the different sections, and, moreover, in the same section the contact of the iris with the cornea was not continuous. The profile of the iris in such a meridional section was wave-like; only the elevations were firmly adherent to the anterior wall of the chamber. The formation of this synechia is, therefore, essentially different from that of the synechia in the glaucomatous eye.

How the attachment is brought about can be seen from the preparations. The surface of the swollen iris is covered by sticky pus-corpuscles, and in some places also with a coagulated structureless mass. The surfaces of the iris and of the lateral wall of the chamber, which are normally almost vertical to each other, are hereby approached and become united. The round arch which the profile of the sinus of the chamber forms is thus changed into a pointed arch, and the chamber is rendered shallower. The anterior surface of the iris approaches the cornea by the progressing attachment between iris and lateral wall of the chamber, and finally comes in contact with it and is agglutinated to the tendon of the ciliary muscle, the ligamentum pectinatum, and Descemet's membrane. All these parts are covered by pus-corpuscles. The condition of the aqueous humor, no doubt, favors the formation of the synechia, for the aqueous is in many cases of cyclitis very viscid, rich in albumen and coagulable. After iridectomy in inflamed eyes, we sometimes observe synechiæ between some portions of the iris and the cornea, without any inflammation or lesion of the corresponding cornea. After extractions which are followed by cyclitis, the escaping aqueous is sometimes so thick that it possesses almost the consistency of the vitreous, and in anatomical examinations I found an amorphous coagulated mass in the anterior chamber of cyclitic eyes, the contents of which, before death, had appeared normal.

The relation of the peripheral synechia in the glaucomatous eye to the increase of tension is explained by the influence which the iridectomy exerts upon the continuation of the synechia. In a woman who was treated in *v. Jaeger's* clinic for retinitis Brightii, acute glaucoma developed (3). During the months preceding the glaucomatous attack, the patient had, of course, been frequently examined with the ophthalmoscope, and the absence of externally visible changes had been daily noticed at the visits; in this case, therefore, we have the best possible guarantee that no glaucomatous symptom whatsoever had preceded the acute glaucoma. A few hours after its outbreak, iridectomy was made. The result was most favorable, and continued unchanged up to the death of the patient, some months after the operation, during which time she had remained in the clinic.* We can hardly imagine a case in which the increase of tension had appeared more suddenly and distinctly, and in which all the symptoms amenable to treatment had, after a short duration, been cured more promptly and completely than in this case (3). Also here the peripheral synechia was very marked; it had been severed to the extent of the coloboma by the iridectomy, but during the healing process of the wound it had reappeared more extensively than before the operation, and even more so than it would ever have been without interference (see Figs. 1 and 2).

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* In June, 1877, I treated a case of hemorrhagic glaucoma, which deserves a short mention on account of its origin and course. A woman, 77 years old, came to my clinic on June 5th, 1877, with excruciating pain in the left eye, in consequence of a contusion received four weeks previously, by a birch-twig striking the eye. The pupil was dilated; slight iritis, cornea opaque, fundus invisible, tension increased, S. reduced to counting fingers at 0.75 m. A series of remedies which I employed to alleviate the pain proved unsuccessful; eserine had no effect. June 13th, I made sclerotomy. The pain disappeared, and on the 14th, I found in the fundus numerous hemorrhages of the size of the optic disc; diminution in the calibre of the vessels and pallor of the non-excavated disc; in the vitreous were numerous fine, floating opacities. On the 15th, the pain reappeared. Eserin made the pupil perhaps a little narrow, but did not change anything in regard to the pain and the abnormal tension. On June 19th, I performed iridectomy. The first night was free from inconvenience, but in the second she had pain and could not sleep. The cornea was again opaque, punctated, and the picture was the same as before the sclerotomy.

It is erroneous to suppose that iridectomy in glaucoma acts by establishing the communication between the anterior chamber and *Fontana's* spaces. We miss the curative effect of the iridectomy only in very few cases, and it must therefore be dependent upon a necessary and regular change produced by the operation. The relation of the stump of the iris to the anterior wall of the chamber varies in different patients, is the result of casualties, and very frequently directly opposite to what *Knies'* and *Weber's* doctrines require, without thereby endangering the effect of the operation. I have examined a number of operated eyes in which the iris had been perfectly removed, in which no remnants of iris were left in the coloboma, or where only here and there small atrophic shreds persisted (2, 5, 15, 16). In others a stump of iris had been left along the whole extent of the coloboma, and was either unattached (14), or folded along and pressed against the lateral wall of the chamber, or was firmly attached to it, to the ligamentum pectinatum, and the membrana Descemetii up to the inner wound (1, 3, 6, 7). When the surface of the peripheral zone of the iris is perfectly free before the iridectomy, it sometimes becomes attached to the lateral and anterior walls of the chamber in

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On June 23d, I began to make frequent instillations of atropine to allay the pain. They acted excellently, and we now had the effect which in ordinary forms of acute glaucoma we see following immediately after the iridectomy. On July 7th, I discharged the patient with still somewhat increased tension, but perfectly clear cornea; fingers were counted at 0.30 m.; pain had been entirely absent for eleven days. The ophthalmoscopic image was as on June 14th. I one case of acute glaucoma in an eye with hemorrhagic retinitis, which I observed in *v. Jaeger's* wards, in 1876, the iridectomy had exactly the same effect as in ordinary acute glaucoma.

consequence of the operation (1 and 13 of the first article). This probably takes place whenever the operation causes an anterior synechia by the healing in of the iris into the inner wound—a fact which occurs much more frequently than we are usually led to suppose, and than we can demonstrate during life. But also in those cases in which the stump of iris does not reach the inner wound, we find it firmly agglutinated to the lateral and anterior walls of the chamber, whilst in the other portion of the chamber the iris is in its normal position (1).

If iridectomy is made in an eye in which the sinus of the anterior chamber is obliterated, it may happen that the synechia is torn by traction on the iris, and that the stump does not become attached again to the neighboring parts (14); but in some cases in which the iris has remained free for some time, a new synechia is formed similar to the former, or surpassing it more or less in extent and intensity (3, 5, 7).

The first case in which the post-mortem appearance was apt to raise doubts against *Knies*' theory, has been reported by the author himself.* The persistence of the obnoxious synechia in a globe the tension of which after an iridectomy had continued normal, leads him to the conclusion that a new drain for the intraocular fluids must have been established by the iridectomy acting vicariously for the impassable *Fontana's* spaces, and that the section only could constitute this new drain.

The hypothesis that the cicatrix favors filtration is based upon the appearance of the cicatrix in many eyes operated on for glaucoma, upon the results of the sclerotomy as an operation for glaucoma, and upon the influence of *Wecker's* filtration loop upon the glaucomatous symptoms. The argument first mentioned was shaken by many clinical observations ; the results of the anatomical examination I shall give later. At the end of the first part of this paper, I have stated the reasons which led me to believe that the filtration through the cicatrix is not the cause of the favorable effect of iridectomy or sclerotomy on the glaucomatous process. The diminution of the glaucomatous tension by the filtration loop depends undoubtedly upon the opening of a permanent channel for the fluids of the eye which are secreted in abnormal quantities. I also do not doubt that any other operation which would open another outlet from the chamber would reduce the tension to, and even below the normal. The fact that the filtration loop acts at least as efficaciously upon the anomalies of tension as the iridectomy and the sclerotomy, must certainly be admitted; but I must declare myself against the conclusion that all these operations have the same effect in the same manner, and that iridectomy and sclerotomy act as the filtration loop by forming a new outlet. The filtration loop acts as a double corneal fistula. The appearance of an eye operated by iridectomy with a good result has no resemblance to one with a corneal fistula. I am just now treating a girl who has a capillary fistula in an adherent leucoma. As soon as the fistula is closed, the tension increases, since secondary glaucoma threatens to ensue; as soon as the fistula is opened, the tension goes down below normal. In keeping the fistula open, we would have a means to prevent the eye from acquiring secondary glaucoma; it would act like the filtration loop, but not like the iridectomy. All this I have only said against the conclusions which are drawn from the effect produced by the filtration loop. I cannot explain the fact, that after the removal of the filtration loop the effect remains undiminished for three months;* but I will remark that there is also no reason to assume that this phenomenon is the result of filtration through the cicatrices of the punctures.

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* Arch. of Ophth., Bd. XXII., 3, p. 200.

A great power of filtration is regarded as a peculiarity of the cicatrices resulting from iridectomies for glaucoma, and it should therefore be due to conditions belonging only to the iridectomy for glaucoma. As such conditions are mentioned the situation and size of the cicatrices, and, moreover, their existence in eyes with a difficult excretion of the fluids (*Wecker*) or with potential glaucoma (*Knies*). Other sections made for different purposes through the tunica externa have the peripheral location, and very frequently also the size, in common with the incision for glaucoma, without influencing the tension of the globe. We could, however, it seems to me, not undisputedly maintain that the cicatrix of the iridectomy in glaucoma could not influence the filtration, because the same iridectomy in leucoma centrale, or the cicatrix from an extraction, does not apparently change the filtration. For it is not impossible to imagine that in normal secretion one drain should not be used which, under abnormal conditions, attains great importance.

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* Cf. *v. Wecker*, Glaucom und Augendrainage. Arch. f. Ophth., Bd. XXII., 4, p. 214.

In ten eyes with iridectomies, six for glaucoma, and the rest for other diseases, I found the anterior wound in some cases immediately behind the margin of Bowman's membrane, and never further than 1.30 mm. backwards from it; the posterior wound in some cases 0.25 mm., in others, 1.75 mm. before the margin of Descemet's membrane. In transverse sections I found the anterior wound 0.66 mm. behind Bowman's membrane, and the posterior 0.89 mm. in front of the margin of Descemet's membrane. Every radius of the eyeball drawn to the margin of Bowman's membrane runs in the external tunic exclusively through corneal substance; the prolongation of a radius drawn through any point of the margin of Descemet's membrane to the surface of the sclera, passes only through scleral fibres. But all the radii which, before they reach the scleral surface, go through a point in front of the edge of the membrana Descemetii, pass partly through corneal and partly through scleral fibres. If the canal of the wound has the same length, the scleral portion will be the greater, the farther the puncture is behind the edge of Bowman's membrane, and the nearer the cut is to the margin of Descemet's membrane. When the operator inserts the blade of the lance-shaped knife always in the same angle to the surface of the eyeball, and therefore (the thickness of the external tunic taken as a constant) the length of the canal of the wound remains always the same, and if the distance of the anterior wound from the margin of Bowman's membrane is also taken as the same in all cases, then still the third portion, which is important in determining the length of the wound in the sclera, *i. e.*, the distance of the posterior wound from the margin of Descemet's membrane, will vary according to the meridian in which the knife is inserted. The transition of the scleral into the corneal fibres occurs in the posterior and middle thirds of the thickness of the external tunic, all around about at the same distance from the axis; but in the anterior third, as is well known, the scleral fibres reach much farther toward the centre of the cornea in the vertical than in the horizontal meridian. Therefore, a wound-canal of the same length, and beginning at the same distance from the margin of Bowman's membrane, will pass with a greater portion through scleral fibres when the incision is made in the horizontal than when it is made in the vertical meridian. In fact, most iridectomies for glaucoma are made upwards, and the point of entrance is rarely much more in the sclera than what I have found on an average in the ten cases mentioned above, *i. e.*, 0.66 mm. behind the margin of Bowman's membrane. Thus only a very small portion of the wound passes through scleral fibres. I found, at the most, one-third of the whole length of the wound lying in the sclera (17), and this most favorable relation was only rendered possible because the plane of the wound was not straight, but curved, and the canal of the wound consequently being uncommonly long and flat. In one case (3)—it was an iridectomy for glaucoma with a good result—the canal of the wound was situated immediately behind Bowman's membrane, and hence only a minute portion lay in the sclera (cf. Fig. 2). In the examinations of sections I found about one-fifth of the whole length of the wound in the sclera.

In iridectomies which were still in the process of healing, and also in their consolidated cicatrices, I found that, on the whole, the conditions are the same in the sclera as in the cornea. In fresh wounds I found both surfaces of the wound covered with a thin layer of a finely granulated substance and very transparent spindle-shaped and roundish cells, which are produced by the surfaces of the wound (15). After firm cicatrization, the injury of the sclera could generally be recognized only by the twisting of the fibres, the interruption of their course, and the slight displacement of their ends. These anomalies are so trifling that we ordinarily cannot even discover the place of the former wound. The cicatrix is much more marked in the cornea. In stained preparations we find the cicatrix more strongly and uniformly colored than the neighboring tissue We find a stripe pervading the cornea in the direction of the wound, and interrupting the course of the fibres the ends of which are displaced near it. The cicatrix is furthermore characterized by spindle-shaped cells with their longitudinal axes in the direction of the wound, by pigment granules, or pigmented corneal cells. The cicatrix is very narrow and certainly firmer than the neighboring tissue, for we miss here the lymph-spaces, which we find on its right and left sides in the corneal substance (14). We observe essential deviations from this mode of healing, when the canal of the wound is obstructed by tissues belonging to the conjunctiva or iris, and when the operation is performed in inflamed tissues (3, 6, 7). Between the surfaces of the wound, which may be widely separated, there is found blood, pus, pigment, and when the cicatrix is consolidated, it constitutes a soft, loose substance, at times delicately fibrillated (1). As the most frequent cause of such irregular healing processes I found iris imbedded in the canal of the wound. Gaping of the wound or imperfect cicatrization is then generally observed in the corneal portion of the wound, whilst these anomalies are rare in the scleral portion.

The healing process of the scleral wound is the same, whether the eye had been operated for glaucoma or not. A very instructive proof of this is furnished by the meridional section through the cicatrized wound of a sclerotomy, as represented in Fig. 3. The incision made with a lance-shaped knife had the most peripheral position such a section can have. The outer wound lay in the horizontal meridian, 1.1 mm. behind the margin of Bowman's membrane, and the inner wound very little backwards (!) from the margin of Descemet's membrane. The whole extent of the cut was, therefore, in the sclera, and yet the cicatrix was firm, the connection direct, and this is the more worthy of notice as the wound healed under continually and much increased intraocular tension and inflammation of the ciliary body! *The scleral cicatrix, then, possesses no peculiarity of structure by which its imputed function as a filtration tissue could be accounted for.*

Also *v. Stellwag's* opinion, that the lesion of the sclerotic in iridectomy for glaucoma gives rise to the formation of loose connective tissue in the dense sclerotic, is contradicted by the results of anatomical examinations. I can, however, perfectly confirm the statements of *Lubinsky*, upon which *v. Stellwag*, relies.* Fig. 4 shows a section through the cicatrix of a scleral wound penetrating into the vitreous body, and inflicted four weeks before the enucleation of the eye. We see that between the lips of the scleral wound a very soft cellular tissue has entered, which is in connection with the choroid. But this kind of lesion is different from that of iridectomy, and therefore both the anatomical condition of the cicatrices and their appearance during life differ. We see very distinctly, even during life, how the lips of the scleral wound become separated and a whitish, translucent mass is interposed between them.

The view according to which iridectomy owes its curative power only to the first step of the operation has of late gained firmer ground. To the second step of the operation, *i. e.*, the excision of a piece of iris, no other significance is ascribed but that it renders the wound clean by removing the iris which is pressed between its lips, or that it prevents a prolapse of the iris later on. *Knies* adopts this opinion, and observed that, in a case of glaucoma treated by iridectomy and followed by impaction of iris, the impaction could render the result of the operation perfectly illusive.† Clinical experience on eyes in which sclerotomy had been performed, and anatomical examinations of cicatrices after iridectomy, have convinced me that the exsection of iris in the operation for glaucoma plays quite a different part from that of a preventive of possible danger. The experiments with sclerotomy as a glaucoma operation have taught us a very important fact, but have also led us to a wrong conclusion. The fact is, that the exsection of a piece of iris is in itself entirely unnecessary for the cure of glaucoma; the mistake lies in the interpretation that the interposition of a cicatrix into the external tunic constitutes the curative element of the glaucoma operation. Neither the exsection of a piece of iris nor the cicatrix in the tunica externa stops the glaucomatous process; but this is done by a third, as yet unknown, factor, which may be at play in either of the two operations (and perhaps also in myotomy), and which in sclerotomy is present only sometimes, only accidentally, but in the regular iridectomy always.

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* *V. Stellwag*, Lehrbuch der praktischen Augenheilkunde, 4 Aufl., page 356; *Lubinsky*, über die den Augapfel penetrirenden Wunden, etc., Arch. of Ophth., Bd. XIII., 2, page 377.

† L. c., p. 200.

To understand the changes in the iris of the glaucomatous eye it is necessary to consider the condition of surface synechia. The sudden advance of the iris in acute attacks, its discoloration and progressive atrophy, can be very well understood from the existence of the synechia and the mode of its occurrence.

I can here omit the summing up of the reasons why I cannot agree with the explanation of *Knies* as to the mode of formation of the synechia. From all I have said it is clear that the iris is not drawn towards the cornea, but that it is pressed against it from behind, and that the inflammatory processes by which the contact is changed into an adhesion do not precede the former, but follow it. *Weber* concludes from his post-mortem examinations that the swollen ciliary processes press the iris forwards.* Case 4 shows that the occurrence of an acute attack of glaucoma with exquisite inflammatory symptoms, the highest degree of intraocular tension, and apposition of the iris and cornea is possible in an eye in which, by pre-existing atrophy of the ciliary processes, their apices are farther distant from the axis of the eye than in the normal condition, and that during the attack the ciliary processes must not necessarily be swollen. I mention this observation, since from it a positive and valid conclusion can be derived, as well as from the result of a simple experiment. The eye was enucleated during a very severe attack of glaucoma; it was the first attack of the eye, and its severity was not less at the time of the enucleation than it had been at the beginning. I think the manner in which the occurrence of the glaucomatous synechia was generally explained before *Knies* and *Weber* is correct. The fluid of the posterior chamber, being under an increased tension, presses the iris against the cornea, and the abnormal contact becomes the cause of the adhesion.

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* *Weber*, die Ursache des Glaucoms, Arch. f. Ophth., Bd. XXIII., 1, p. 64.

In eyes with increased tension and glaucomatous symptoms in their anterior segment, the synechia is only exceptionally absent. But when the glaucoma is diagnosticated with the ophthalmoscope only, and no glaucomatous symptoms are found in the anterior portion of the eye, synechia may not have developed. Both eyes of Mr. H. were the only ones in which I found the iris in its normal position (1 and 2); unfortunately I have no accurate details of the history, but the anatomical examination, combined with the dates at hand, warrants the supposition that also during life and before the operation no striking changes had existed in the anterior segment of the globe.

Apart from the changes in the visible portion of the iris, there would be only one symptom by which we could recognize a synechia during life, when it has extended beyond the margin of Descemet's membrane. If we illuminate a normal eye obliquely and throw the point of the cone of light upon the disc of the iris, we can see around the cornea a circular scleral zone illuminated by the light coming from the anterior chamber. The margin of this illuminated zone corresponds to the margin of Descemet's membrane and its breadth is equal to the breadth of that piece of the external tunic, in which the corneal substance is covered by scleral tissue. The breadth of this illuminated zone must decrease as soon as the iris becomes attached to Descemet's membrane. In glaucomatous eyes, we shall very rarely be able to demonstrate the synechia in this manner, since generally the radius of the agglutinated zone of iris is not longer than the distance of the root of the iris from the margin of Descemet's membrane. In case 4 I had stated the complete absence of the illuminated zone during life; and the anatomical examination showed that the iris was in close contact with the membrane of Descemet, though not adherent to it.

The changes which I have observed in *Schlemm's* canal refer only to its calibre, and have no constant relation to the other glaucomatous symptoms. In well-developed cases of glaucoma, I have found rather frequently *Schlemm's* canal normal (3 and 5). Since, on the other hand, closure of the canal occurs without any clinical symptoms which could indicate it (cf. first article), and since the iridectomy has no constant influence upon the re-establishment of its calibre, I am not able to say whether there are any symptoms in the clinical picture of glaucoma that are the consequence of a compression of *Schlemm's* canal. Such an interpretation could, at any rate, only be based upon a certain knowledge of the significance of this canal. But we do not know yet with certainty whether *Schlemm's* canal conveys blood. Although I have made numerous sections through the external tunic of healthy and diseased eyes, I have found blood in *Schlemm's* canal only a single time (cf. first article, 2). In this case it came undoubtedly from without. Even in the two eyes of a young man who had committed suicide by hanging, I found the canal widely gaping and empty, whilst the vessels of the uveal tract were strongly filled. In inflamed eyes, in which *Fontana's* spaces abounded with pus-corpuscles, I found the walls of *Schlemm's* canal pressed together, so as to obliterate its calibre, but the scleral vessels were overfilled with blood. The calibre of the canal is influenced by the condition of the tissue filling the scleral channel, but not at all analogous in size and contents to the vessels around the canal. The canalis *Schlemmii* does not communicate directly with *Fontana's* spaces, for whenever we find the latter filled with blood, pus, or pigment, we surely see the canal surrounded by these elements, without, however, discovering them in its lumen.

In recent cases of glaucoma, the iris shows hyperæmia, small hemorrhages, and an unusual rigidity of the tissues. I have convinced myself that in exsected portions of iris taken from recent cases of glaucoma acutum the anatomical condition is as different from that in iritis as the clinical picture. In older cases, we find the iris always thinned, blood-vessels scanty, the pigmented cells of the iris-stroma pale and many heaps of pigment dispersed through the tissue. Inflammatory infiltration we observe only when also in the clinical picture the complication with iritis is well marked. The opacity of the aqueous humor in some cases of inflammatory glaucoma is, as I have shown before, caused by pigment molecules which were detached from the posterior surface of the iris.

Once I met in the posterior chamber a pathological structure which has perhaps an important relation to the glaucomatous process. The history of the case is shortly as follows: I operated on a man, 71 years of age, for glaucoma simplex on both eyes. Externally the eyes showed so little deviation from the normal that I could make the diagnosis of glaucoma only by the ophthalmoscope, but the tension was very much increased, and there was also arterial pulsation extending beyond the area of the papilla. In consequence of previous choroiditis and posterior staphyloma, the acuteness of sight in the right eye was almost 0, in the left $\frac{6}{9}$. (The influence of the intermittent flow of blood into retinal vessels in increased intraocular tension is very often more unimportant than is generally supposed; I have observed even normal sight with exquisite arterial pulsation caused by glaucoma.) In making the iridectomy in the left eye, nothing remarkable occurred; but in the right, with and behind the iris, a grayish mass prolapsed which resembled very much a small lump of semi-opaque cortical substance. This mass was two to three times as thick as the exsected portion of iris and had the same area; it did not cohere with the iris, but was simply lying close to the uvea. Before the operation, as I have mentioned, the anterior chamber, the iris, and the movements of the pupil were such as not to arouse my suspicion in any direction; also, after the operation the eye did not show any deviation from the normal appearance of an eye after iridectomy. Professor *Schott* examined the pathological tissue and made the following statement: "The thin, whitish membrane is pervaded by delicate, straight, or somewhat tortuous connective-tissue fibrillæ, and contains a few elastic fibres, numerous larger and smaller blood-vessels filled with red blood-discs, and around them a larger quantity of fibrillar connective tissue, in which numerous cells are imbedded. Here and there, small, roundish brown pigment corpuscles lie upon the surface. Through the delicate membrane a mosaic of epithelial cells can be traced; the protoplasm of the cells is finely granulated around the oval nucleus and more homogeneous in the periphery. There are also irregularly distributed cells with perfectly homogeneous protoplasm and shrunken nuclei." The exsected piece of iris was thinner than normal, but showed no other changes. When I spread the exsected portion of the left eye out and examined it more accurately, I found also here a pathological membrane slightly adherent to the uvea, but much thinner than in the right eye; its main portion consisted of endothelial cells, as *Schott* had found also in the right eye. No blood-vessels were found. A similar condition has, as far as I know, not yet been described. What relation it bears to the glaucoma I cannot conceive, and I would not have mentioned the fact at all, if Prof. *v. Jaeger* had not told me that he had been surprised by a similar occurrence in three iridectomies for glaucoma. Also my friend Dr. *Kerzendorfer* in Vienna has observed a mass of grayish exudation after the exsection of iris in a case of glaucoma. The patient had, in 1872, been operated by Prof. *v. Arlt* for simple glaucoma at the age of 64. In 1877, acute glaucoma set in in the same eye, and Dr. *Kerzendorfer* made a second iridectomy. "As soon as the iris had been removed, a small lump, looking like lens matter, issued from the wound." The effect of the operation was only of short duration, for hardly five weeks afterwards a very severe attack ensued. Enucleation was proposed but not accepted; instillation of a one-percent solution of eserine and a subcutaneous injection of morphia caused the rapid disappearance of the glaucomatous symptoms.

The ciliary body was perfectly normal only in the two eyes with simple glaucoma (1 and 2). In the two cases of secondary glaucoma with staphyloma, the pathological changes could not be brought into any connection with the glaucoma. In one of the cases (12), the ciliary body was changed in correspondence with the stretching of the walls of the eye; in the second, a slight atrophy of the ciliary muscle could possibly be taken for a glaucomatous change (13). But in all the other nine cases, the ciliary body showed changes which could only be attributed to the glaucomatous process. In the recent cases, the ciliary muscle had become smaller by a simple thinning of the muscular layers in all the portions of its body and all around its circumference. It had retained its form, the relation of the different portions had not been changed, but the muscular body had decreased in size. In older cases, I did not find all the portions of the muscle equally affected, the layers next to the inner and posterior edge of the muscular ring being much more atrophied. Thereby the muscle changed its form; in sections it appeared spindle-shaped (4), and the greatest breadth was about at the junction of the anterior and middle thirds. The meridional bundles which join the sclera persisted longest (9 and 10). These also finally become atrophied, and the processus ciliares lie then directly upon the sclera (11).

As deviations from the just described condition, I found in two cases that the atrophy of the muscular fibres was not of the same degree at all places, and that there was in some places not only atrophy of the muscular elements, but also increase of the connective tissue (5 and 7). Pus-corpuscles were seen in the ciliary muscle only with simultaneous inflammatory infiltration of other parts. A proliferation of nuclei, as described by *Brailey*, did not appear in my preparations.

The ciliary processes were either normal or atrophic. They were inflamed only in those cases in which also during life the diagnosis of a complicating cyclitis had been made.

It is *Brailey's* great merit to have first observed and described the atrophy of the ciliary muscle.* This is the only anomaly in the glaucomatous eye demonstrated hitherto by the anatomical examination, which has undoubtedly a relation to the glaucomatous process and is not merely a consequence of it. It exists before the glaucoma can be clinically diagnosticated, for I found it very nicely developed in a globe in which the increase of tension had existed only for a few hours (3). The highest degree of atrophy is certainly only found in eyes in which the glaucoma had existed for a long time; but the increase of the atrophy, it seems to me, does not stand in a direct proportion to the duration and the degree of the increased tension. Thus in case 3, where the tension had been increased hardly for one day, the atrophy was greater than in case 7, an eye which more than six years before the enucleation had become blind by the first attack of acute glaucoma.

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* *W. A. Brailey*, On the Pathology of Increased Tension of the Globe. The Royal London Ophthalmic Hospital Reports, Vol. IX., 2, page 199.

In all the cases of primary inflammatory glaucoma which I could examine, and in one case of hemorrhagic glaucoma, I found a pronounced atrophy of the ciliary muscle. Thus this remarkable form of secondary glaucoma is brought nearer to the primary glaucoma.* The absence of the atrophy in case 12 seems very remarkable to me for two reasons: here the glaucoma had existed probably for twenty years, had distended the globe immensely, and produced the deepest excavation of the papilla that I ever measured. This case shows that the atrophy of the ciliary muscle must not necessarily precede or follow a high and long continued increase of tension. The second fact could also be deduced from the consideration of the conditions in primary glaucoma. The first demonstrates an important anatomical difference between certain forms of secondary and primary glaucoma.

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* Also *Knies* describes a case of hemorrhagic glaucoma which he had examined anatomically (l. c., p. 168), and in which he found the same change of position of the iris as in all the other cases of primary glaucoma. He says, l. c., p. 195: "Also for the hemorrhagic glaucoma it is easy to understand, that with a special predisposition, the abnormal elements in the vitreous body, which find their outlet from the eye through *Fontana's* space, may here lead to a circumscribed inflammation." Why do these abnormal elements irritate and cause inflammation shortly before they are discharged from the eye? Why do the abnormal elements of retinal hemorrhage, and no other forms of retinal disease, etc., cause such inflammation?

My clinical experience leads me to suppose that the source of the glaucomatous increase of tension is the same in all the cases, and that the varieties of the occurrence and course of the single attacks of glaucoma are due to the difference in the first impulse causing the glaucoma.

I am also convinced, from my clinical experience, that the iridectomy cures in all the cases only by one change which is directed against the next cause of the increased tension. I cannot adhere to *Schmidt's* idea, that the iridectomy contains a sum of heterogeneous remedial measures, every one of which corresponds to a different cause for the glaucoma, and that knowing what could produce glaucoma, but not knowing what has produced the increase of tension in the individual case, we offer the glaucomatous eye, by the iridectomy, a collection of possible remedies of which the one or the other may act.* This opinion of the author seems more apt to please the theorists than to satisfy the theory.

The staphylomatous distention of the zone of the eye situated between the corneal margin and a line drawn through the insertions of the recti muscles is, as far as I could observe, always followed by increase of tension, without, however, as case 12 shows, always producing atrophy of the ciliary body. But the shrinking of the ciliary body is always attended by a change which is exceedingly pronounced in those staphylomata, *i. e.*, the crests of the ciliary processes change their position, and the diameter of the circle formed by the ciliary processes becomes larger. Atropine and eserine, which in normal eyes do not influence the tension in a measure recognizable by our clinical methods of examination, change it, when glaucoma is impending or already existing, very frequently in a most striking manner. The atropine, which increases the tension, enlarges the distance of the ciliary processes from the axis, the eserine, which diminishes the tension, lessens this distance. I have remarked before that with atrophy of the iris and the

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* Handbuch der gesammten Augenheilkunde, V., Bd. I, Theil I, I. Hälfte, p. 118.

ciliary processes normal tension and glaucoma are perfectly compatible; but the bulbus always becomes soft if, by the process which produces the atrophy, the anterior scleral aperture, and with it the circle of the ciliary processes, has been made smaller. The latter change is, as far as my experience goes, constantly connected with reduced tension of the eyeball. Only recently I had occasion to observe, in two cases of injury in the ciliary region, from the time of the injury, during the long period of inflammation, and after its abatement, a continuous hypotony of a high degree. It is well known that hypotony occurs very frequently in hyperæmia of the anterior segment of the eye (in keratitis, iritis, cyclitis); in those cases we are entitled to suppose that the ciliary processes advance toward the lens in consequence of the greater supply of blood. This consideration might perhaps prove fruitful for the explanation of the curative effect of the iridectomy. It is certain that iridectomy, as well as sclerotomy and myotomy, can bring about a displacement of the corresponding portion of the lateral walls of the anterior and posterior chambers; my preparations show that, in a successful iridectomy for glaucoma, the ciliary muscle and the processes were strikingly drawn inwards; in the three other iridectomies for glaucoma which I examined, I found quite similar changes. This displacement seems, therefore, to be of regular occurrence, and is produced probably by the stretching of the iris, when, during the operation, we try to excise as peripherally as possible. In a subsequent article I shall try to substantiate these views, if I should succeed in obtaining more anatomical material and arriving at positive conclusions.

We might be led to suppose that the atrophy of the ciliary muscle in glaucomatous eyes might perhaps only be an exaggeration of that condition to which the ciliary muscle is commonly subject by the marasmus of the eye. From numerous examinations of the eyes of old people, I have been convinced, however, that the senile atrophy does not cause a similar atrophy of the muscle. Up to the sixtieth and even sixty-fifth year, the muscle does not at all show any apparent decrease in size. At a higher age, the meridional plates appear sometimes thinner, and the muscle is then in its middle and posterior thirds made up principally or exclusively of meridional bundles not quite as large as in young eyes. In this senile atrophy the muscle sometimes appears shorter. But if we measure the thickness of the muscle at a small distance from the tendon, we do not find, even in the eyes of the oldest persons, any deviations from its size in young eyes. Thus in seven eyes of five individuals at the ages of 80, 81, 82, 83, and 84 years, I found the greatest thickness of the ciliary muscle at a short distance from the tendon = 0.690 mm.

In the choroid of many of the eyes, inflammatory changes were found consequent upon processes implicating the choroid. As to the importance of these inflammatory processes in the choroid in regard to glaucoma, we must consider that they are not found regularly, and that they can also be diagnosticated during life as independent, pre-existing, or supervening troubles after a long existence of the glaucomatous process. Exquisite cases of glaucoma do not show a trace of inflammatory changes in the choroid, whilst exquisite inflammations of the choroid take a course quite unlike that of glaucoma. Pus-cells are observed in the choroid not only in all forms of choroiditis with normal and reduced tension, but also in iritis, keratitis, etc. The occurrence of round cells in the choroid in some cases of glaucoma is, therefore, not very important; the glaucomatous process, which is clinically so extremely different from those diseases, does not become clearer by alluding to anatomical conditions which it has sometimes in common with them. The most regular alteration I found was a slight atrophy of the tissue, a thinning of the choroid. The slight filling of the choroidal vessels appears very remarkable to me, and does not well agree with the supposed congestion of the venæ vorticosæ. In case 4, in which the bulbus also after the enucleation showed an enormous hardness, the choroidal vessels were less filled than we find in the sections of normal eyes. What has been said about the inflammatory changes sometimes present in the choroid of glaucomatous eyes concerns also the inflammatory changes in the vitreous body.

About the changes in the retina and optic nerve I have nothing new to remark.

I have found the sclera of glaucomatous eyes exactly the same as in healthy individuals of the same age. In old age, the sclera becomes rigid. If we remove the eye of an old person soon after death and cut it open, we observe that the two halves do not collapse, but retain their shape even after the removal of the contents. This was the condition of the sclera in case 4, in which I divided the globe four hours after the enucleation, and in case 11, in which the eye was opened fourteen hours after the death of the patient. But in both the choroidal veins uniting to form the vortices were empty. Under the microscope we see that the scleral fibres of all the eyes are stiff and straight, whereas in young persons they have a wavy course and are flexible.

In order to see how the scleral canals through which the venæ vorticosæ pass, behave during increased tension of the tunics of the eyeball, I injected fluid into the vitreous chamber of old persons until the globe felt very hard. After the walls had (once) become tightly stretched, the fluid, being under continued pressure, oozed from the canals through which the venæ vorticosæ pass. This experiment succeeded also after I had introduced needles of $\frac{5}{6}$ mm. in thickness into those canals, the fluid then dripping down from the needles.

To ascertain whether the sclera of aged eyes shrinks and thereby envelops more tightly the contents of the eyeball, I measured a number of eyes of old persons. The following table contains the results which I have obtained.

A. WOMEN.

Age.	Hours from death until examination.	Antero-posterior diameter.	Transverse diameter.	Vertical diameter.
63 years. ..	44	21.0 mm.	21.6 mm.	20.3 mm.
	46	21.0 “	22.5 “	20.3 “
63 “ ..	12	22.5 “	22.5 “	20.7 “
	12	22.5 “	22.5 “	21.6 “
64 “ ..	41	21.3 “	21.6 “	21.0 “
	41	21.3 “	21.3 “	21.3 “
68 “ ..	48	22.5 “	22.5 “	....
	48	23.1 “	23.1 “	21.4 “
68 “ ..	50	21.3 “	21.3 “	25.3 “
	50	21.3 “	21.3 “	20.4 “
73 “ ..	23	21.9 “	21.6 “	20.2 “
	23	21.9 “	21.3 “	20.4 “
74 “ ..	36	23 “	22.8 “	....
	36	23.4 “	22.5 “	22.5 “
77 “	10	23.7 “	22.2 “	21.6 “
79 “ ..	47	22.5 “	21.9 “	21.6 “
	..	22.8 “	21.6 “	21.9 “
80 “	49	22.5 “	21.0 “	21.0 “
81 “ ..	31	22.5 “	22.5 “	21.6 “
	..	22.5 “	.... “	....
82 “ ..	49	23.4 “	23.4 “	....
	..	23.1 “	22.8 “	....
84 “ ..	17	23.1 “	22.2 “	21.9 “
	17	22.8 “	22 2 “	21.9 “
86 “ ..	25	23.7 “	22.5 “	....
	..	23.2 “	22.6 “	22.2 “

It appears, therefore, that of twenty-six eyes from fourteen individuals, the youngest of whom was 63, the oldest 86 years of age, the axis had a length of at least 21, at the highest 23.7 mm. In these individuals, the antero-posterior diameter had an average length of 22.4 mm.; the transverse, 22.1; and the vertical, 21.2 mm. Upon a number of these measurements I based my remark “that the eyes of old persons are in all diameters smaller than young eyes, and that we could *safely* say that the involution leads to a concentric atrophy of the eyeball.” (Zur Lehre von den Ursachen der Kurzsichtigkeit, Arch. f. Ophth., XX., 2, page 59.) But since then, I have been able to measure also a number of bulbi from old men, and I have learned that, what I formerly ascribed to age, was probably to be explained by the fact that I had measured only the eyes of old women. The number of eyes from old men is much smaller, indeed, but the difference of the measurements obtained is very striking.

B. MEN.

Age.	Hours from death until examination.	Antero-posterior diameter.	Transverse diameter.	Vertical diameter
59 years. . .	25	24.3 mm.	. . . .	22.5 mm.
	25	24.0 “	. . . .	22.8 “
62 “ . .	55	24.0 “	23.1 mm.	21.9 “
	55	23.4 “	22.5 “	21.6 “
64 “ . .	45	23.5 “	23.5 “	23.4 “
	45	23.5 “	23.5 “	23.5 “
81 “ . .	45	24.6 “	24.0 “	23.7 “
	45	24.8 “	24.0 “	23.7 “
82 “	9	23.4 “	23.4 “	22.2 “

Of these nine eyes, the shortest had an axis of 23.4, the longest 24.8 mm. The antero-posterior diameter was on an average 23.9, the transverse 23.4, the vertical 22.8 mm.

1 AND 2.

Glaucoma simplex oculi utriusque. Iridectomy in both eyes. Left, blindness by detachment of the retina one year after the operation. Right, good result, lasting until death of patient, 4½ years after the operation.

Franz H., 56 years old. The following dates I obtained through the kindness of Dr. *Friedrich* in Graz. “When I saw the patient the first time, his statements about the sudden decrease of sight were so accurate and so characteristic of glaucoma that, even before an ophthalmoscopical examination, I diagnosed a probable glaucomatous affection of the optic nerve Neither inflammatory symptoms, nor acute attacks, nor any symptoms of a chronic inflammation had preceded. He did not even admit the headache which is so frequent. In the left eye, he had H. $\frac{1}{15}$; in the right, H. $\frac{1}{20}$. L., considerable limitation of the visual field. The ophthalmoscopic examination revealed perfect clearness of the refracting media, an increase of volume of the retinal veins, a pale color, and a not very considerable but indubitable excavation of the optic nerve. I induced the patient to go to Vienna and be examined by Prof. *v. Arlt*, who sent him back to me with a note containing the following words: 'Glaucoma; operation not to be delayed.' On July 24th, 1871, I operated on the left eye, which had been first affected, and on September 2d, 1871, also on the right eye. Later, the first eye became atrophic; the right, in which the process had not progressed so far, had the best visual result we could wish for under the circumstances. Still, in March, 1876, he could read small print with it. During the fall of 1873, he complained of increased indistinctness of vision; the ophthalmoscope still showed the excavation, but the disc appeared paler. L., atrophy and cataract had developed." Patient died on December 13th, 1876.

Left Eye.—Antero-posterior diameter, 22.5; transverse, 23.7; vertical, 22.5 mm.; depth and limits of the angle of anterior chamber were—apart from the results of the iridectomy—perfectly normal, but its wall densely infiltrated with pus-corpuscles. *Fontana's* spaces densely filled with pus-cells, *Schlemm's* canal not visible. In some sections, one of the bands which descend along the lateral wall of the chamber was separated from it and passed as a free cord covered with pus-cells from the anterior wall of the chamber directly to the posterior and was lost in the iris.

Upwards a coloboma with divergent limbs, in the space of which 12 ciliary processes are visible. The cicatrix of the anterior wound lies 0.85 mm. posteriorly from the margin of *Bowman's* membrane. In many meridional sections it is so little marked that it can be accurately determined only by following the canal of the wound to the surface; in some sections it is marked by imbedded pigment, in others by a displacement of the lips of the wound, the peripheral lying a little anteriorly from the central lip. The cicatrix of the posterior wound lies 1.5 mm. from the margin of Descemet's membrane. The cut edges of this membrane are turned up into the canal of the wound and are attached to its surfaces. Corresponding to the cicatrix, the posterior surface of the cornea is either slightly drawn in, prominent, or wave-like by the projecting of one and the receding of the other lip of the wound. A small piece of atrophic iris adheres in many sections to the cicatrix of the posterior wound. The canal of the wound is 1 mm. long; its cicatrix is in some sections very little marked, in others it contains heaps of pigment. In some sections the cut edges of the corneal fibres show slightly bulbous swellings, and between them lies a mass consisting of lymphoid pigmented and unpigmented cells, a few curled fibres, and very numerous clusters of pigment. This intercalated mass does nowhere pass through the entire length of the canal, it mostly lies in its posterior half near Descemet's membrane and in the superficial portion belonging to the sclera there is firm union. The iris is not cut out entirely; its remnants, however, do not project towards the axis of the eye with a free anterior and posterior surface, but are situate on the inner side of the ciliary muscle. The anterior surface of the stump of iris lies upon the lateral wall of the chamber and is firmly adherent to it; its posterior surface faces the axis of the eye, and its cut surface is attached to the anterior wall of the sinus, *i. e.*, to the ligamentum pectinatum up to the margin of Descemet's membrane. In very many sections, a ciliary process is displaced so much forwards and inwards that its folds touch the cornea. In this case the sinus of the chamber was normal before the operation, and in the extent of the coloboma was perfectly obliterated after it. Throughout the extent of the coloboma the tissue of the scleral channel (and of the ciliary body) is not infiltrated. Its lamellæ are compressed, and *Schlemm's* canal has become invisible.

The iris is 0.250 mm. thick, infiltrated with pus corpuscles. The pupil is occluded by a thin, transparent membrane.

The ciliary body shows purulent infiltration; the greatest thickness of the ciliary muscle is 0.875 mm.

The choroid is detached from the sclera in the anterior half of the globe. It is pervaded by pus-cells, especially in its outer layers.

The retina is detached up to the ora serrata and folded cord-like around the remnant of the vitreous. Between it and the choroid lies a coagulated mass containing an intricate network of fine fibres and a great number of cholesterine crystals. The optic nerve shows no anomaly besides the atrophy of its nerve-fibres.

The anterior lens capsule is opaque. The lens itself is transparent. It is detached from the zonula, but fixed between iris and vitreous body by exudation. A broad annular space exists between its margin and the processes. It has a thickness of 5 mm., and an equatorial diameter of 8 mm.

Right Eye.—Sagittal diameter, 22.5 mm.

The whole sinus of the chamber shows typically normal conditions.

There is an upward coloboma, 7 mm. broad at the ciliary, 6 mm. at the pupillary margin, and exposing 11 ciliary processes. The cicatrix of the anterior wound is indistinctly visible with the magnifying glass. Behind the cicatrix the microscope shows a slight depression in the sclerotic, towards which also the fibres of the covering conjunctival tissue converge. It lies 0.75 mm. behind the margin of *Bowman's* membrane. The cicatrix of the posterior wound is slightly drawn in, the lips of Descemet's membrane meeting at an obtuse angle, without, however, being attached to the surfaces of the canal itself. The cicatrix lies 1.5 to 1.8 mm. before the margin of Descemet's membrane. In some sections, atrophic remnants of iris and much pigment are adherent to the posterior wound. The canal of the wound is 0.875 to 1.125 mm. long. The cicatrix is recognizable as a delicate streak, more strongly colored than its surroundings, and becoming the less distinct the more it approaches the surface of the globe, where it passes through the sclera. In many sections, the corneal cicatrix was marked by imbedded pigment which had also entered the corneal cells. In the direction of the cicatrix, there are a few spindle-shaped cells, but no other newly formed elements.

No iris-tissue in the coloboma, and no remnants of it have remained attached to the ciliary body.

The iris is 0.375 mm. thick; the greatest thickness of the ciliary muscle is 0.70 mm.

The optic disc has a partial (physiological) excavation, the bottom of which lies in the plane of the inner surface of the choroid, whilst the lamina cribrosa has its normal form and place.

All the parts of the globe not specially mentioned were normal.

3.

Glaucoma acutum in an eye with retinitis Brightii and numerous hemorrhages. Successful iridectomy during the first attack shortly after its beginning.

Anna Prösselmayer, 66 years old, was admitted to *v. Jaeger's* wards on March 28th, 1877. The impairment of sight in both eyes had commenced in January, 1876. With the right eye the patient counted fingers at 6′; in the left, there was only quantitative perception of light. Externally the eyes showed no abnormity; with the ophthalmoscope, Bright's retinitis with numerous hemorrhages. The left ventricle was hypertrophied, and over the aorta was, with the diastole, a sharp sawing murmur. Feet œdematous. A great quantity of albumen in the urine. On April 18th, 1877, sight was entirely destroyed in the right eye by a very large hemorrhage into the retina and vitreous body. Patient states that on May 23d she had severe headache in paroxysms, which lasted two days. The eyes showed no change, except a decrease of the hemorrhage in the right. At the beginning of June, amaurosis in both. The diastolic heart-murmur had disappeared, but the patient complained of severe palpitation. In the evening of June 22d, she had severe pain in the right side of the head. On the 25th, P.M., the right eye suddenly presented an exquisitely glaucomatous appearance. The corneal opacity made an ophthalmoscopic examination impossible; the chamber was shallow, the pupil slightly dilated and irregular, the tension very high. On June 26th, *v. Jaeger* made an iridectomy outwards. In the evening, the patient was perfectly free from pain. The healing process, as to duration and effect upon the glaucomatous symptoms, was perfectly favorable, but the iris had healed into both corners of the wound. The ophthalmoscopical examination showed the absence of an excavation. On August 22d, patient was confined to bed; on September 19th she died. The autopsy showed: Morbus Brightii chron., pneumonia hypostatica lob. infer. utr.

The anatomical examination of the sinus of the chamber shows that the iris (I do not at present mention the coloboma) is all around agglutinated to the ligamentum pectinatum. The attachment reaches in most places to the margin of Descemet's membrane; in a few sections only it does not reach so far, in others a short distance beyond it. On the whole, the agglutination is only slight; but in some meridional sections it becomes so firm that, when I attempted to separate them, Descemet's membrane would follow the iris. The lamellæ which bridge over, *i. e.*, fill the scleral furrow, can be distinctly traced. Their interspaces are incompletely filled with red blood-corpuscles and clusters of pigment of varying size and form. *Schlemm's* canal is empty, and normal in form and size. The adherent portion of iris is mostly still thinner than its other parts (see Fig. 1); numerous red blood-corpuscles are found in the tissue of the iris. Corresponding to the coloboma, the iris has been separated from the ligamentum pectinatum by the iridectomy, and its stump is dislocated towards the axis of the eye. The ciliary processes, however, are attached to the ligamentum pectinatum. The ciliary body is drawn so much forward that the point at which the iris leaves the ciliary processes is situated in front of the margin of Descemet's membrane. The stump of iris is either firmly attached to Descemet's membrane or it bridges over and adheres to the cornea at the inner opening of wound. The processes are situated in some places opposite Descemet's membrane, and the ciliary muscle has changed its form in such a manner that the angle which looks towards the anterior chamber is nearer to the anterior pole than *Schlemm's* canal, and that the scleral side of the muscle forms a very obtuse angle with the side looking towards the chamber. The lamellæ of the ligamentum pectinatum are, in the extent of the coloboma, also drawn forward; *Schlemm's* canal is here narrower or entirely invisible (see Fig. 2).

The cicatrix of the anterior wound lies directly behind the margin of *Bowman's* membrane in the sclera, exactly opposite the margin of Descemet's membrane. The cicatrix of the posterior lip lies 0.9–1.0 mm. before the margin of Descemet's membrane. The latter is curved around the lips of the wound and attached to the surfaces of the canal. The opposite surfaces are not in contact, and hence the canal of the wound gaps. The canal has an average length of 1.40 mm. and is everywhere well visible in its entire course. We find in it more or less numerous heaps of pigment and red blood-corpuscles; the latter in some places even in small heaps. The cut corneal or scleral fibres curve toward the posterior surface of the cornea, and the ends of the lamellæ are displaced. The stump of iris is everywhere drawn towards and retained in the wound. In some meridional sections the stump is drawn into the middle of the canal, in most of them it reaches a short distance beyond the level of the posterior wound. In the former sections, the anterior surface of the iris is attached to the surface of the canal with which it is in contact, but no union has taken place between the uveal surface of the iris and the corresponding surface of the wound, and a free space exists between the two. The plastic material between the two surfaces of the wound is very small. Some spindle-shaped cells, which traverse the cicatrix in the direction of the wound, are the only newly formed elements. The cicatrix is the less distinct the nearer it comes to the surface of the globe.

In and upon the iris are many red blood-discs. The thickness of the iris is 0.125 mm.

The ciliary processes are normal. The ciliary muscle is considerably smaller on account of atrophic changes. Its form is unchanged, and all its portions have decreased proportionately: its greatest thickness being 0.450, its length hardly 2.0 mm.

The choroid is somewhat thinned, the pigmentary layer perfectly normal, the vessels slightly filled. No trace of inflammatory infiltration or its results.

The greater portion of the retina is detached; between it and the choroid a coagulated grumous mass with many red blood-corpuscles: numerous extravasations of blood into the retina; from the margin of the papilla up to the ora serrata there is not a spot of the size of the optic disc free from hemorrhages which pervade the whole thickness of the membrane. The layers of nerve-fibres and ganglion-cells are in a state of advanced atrophy. The disc is swollen, its level projecting 1.0 mm. over that of the inner choroidal surface.

The vitreous contains a large quantity of red blood-corpuscles.

4.

Very severe attack of acute glaucoma in an eye blind for three years with retinitis pigmentosa and excavation of the optic nerve.

Franz Dezulian, 54 years of age, noticed since 1859 a diminution of sight in both eyes. The left eye grew entirely blind three years ago, the right shows the highest degree of concentric limitation of the visual field, still S. = $\frac{3}{6}$. On Jan. 28th, 1878, the patient awoke with excruciating pain in the left eye, which till then had always been perfectly painless, and since the pain continued undiminished, he presented himself in my clinic on February 16th. The eyeball had the highest degree of tension we can find, the conjunctiva bulbi and the subconjunctival tissue were much injected and moderately swollen, the cornea dull, the pupil ad maximum dilated, the iris atrophic and in its upper segment hardly visible. The upper half of the lens seemed to be in direct contact with the cornea, and there existed a very shallow chamber only downwards. Details of the fundus could not be recognized; upwards and inwards, the margin of the lens could be seen. No light passed through the scleral zone around the cornea; only inwards a dim light could be seen through the sclera. The right eye had retinitis pigmentosa, looked normal externally, and had normal tension. I sent the patient to bed and ordered instillations of a 1% solution of eserine every hour. From his admission until the time of the enucleation, on the following day, eserine had been dropped in 17 times. The pain had not entirely disappeared, but was considerably alleviated; the tension of the eyeball and the size of the pupil had not been influenced by the eserine.*

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* At times, even in a fresh glaucomatous attack, the eserine does not exert any influence at all. A woman, 48 years old, who for a year had every now and then noticed premonitory symptoms in her left eye, had a very acute glaucomatous attack in the evening of February 5th, 1878. 38 hours later I saw her for the first time, and ordered instillations of eserine, since she would not consent to be operated on; from

The antero-posterior diameter of the enucleated eye measured 24 mm.; the vertical, 23.5 mm.; the transverse, 23 mm.; the cornea had 12 mm. in the transverse diameter, 10 mm. in the vertical. The greatest diameter of the iris, as far as visible in front, was 2 mm. The tension of the eyeball was as great as before the enucleation; also four hours later, during which time the globe had lain in Müller's fluid, the tension was very great. The margin of the lens, the greater portion of which was detached from the ciliary processes, was everywhere 2 mm. distant from their crests, and considerably enlarged. The equatorial diameter of the lens was 8.25; the antero-posterior, 5 mm. The distance between two opposite processes was in most instances 12 mm., rarely a trifle more. The processes were small, atrophic, and showed a very different appearance from their hyperæmic, swollen condition in which they project over the posterior surface of the iris, and push against it. Most of the upper processes were atrophic. The breadth of the iris, measured on the posterior surface, was above 2 mm.; outwards, 2½; below and inwards, 3 mm. The horizontal diameter of the pupil, 8 mm.; the vertical, 7 mm. The uveal layer of the iris appeared normal; the pupillary margin showed no anomaly.

The sinus of the chamber was obliterated, the iris being in contact with the inner wall of the chamber, the ligamentum pectinatum, and Descemet's membrane. An attachment, however, existed only between the iris and the inner wall of the chamber, and a portion of the ligamentum pectinatum. The other portion was only loosely adherent to the iris, and became mostly detached during the manipulation. The tissue of the scleral furrow was compressed and contained some pigment. The lumen of *Schlemm's* canal was nearly everywhere distinctly visible, but smaller than usual, empty, and surrounded by granular pigment.

The iris was 0.15 mm. thick, and remarkable for the scanty pigmentation of the stellate cells, and the accumulation of pig-

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3 P.M. until the operation, at 11 A.M. on the following day (Feb. 8th), a 1% solution of eserine had been instilled 10 times without alleviating the pain and diminishing the tension. Only the pupil had become a little narrower.

ment in small heaps. The tissue of the iris being considerably atrophied, the well-preserved uveal layer appeared disproportionately thick.

The ciliary body was atrophic in all its portions. The muscular plates were thinner, and the anterior inner angle of the muscle was entirely wanting. Thus the muscle appeared spindle-shaped in transverse sections, and measured in thickness 0.80 mm.; at the tendon, it measured 0.45 mm. The length of the muscle was not diminished. The processes showed considerable atrophy; the folds were low; this was especially striking near the posterior surface of the iris, an uncommonly great distance being between the first fold and the iris. Neither in the ciliary body nor in the iris was any sign of inflammatory infiltration or abnormal filling of the vessels. If we compare the filling of the vessels in this eye having extreme glaucomatous tension with that in cases 7 and 8, in which eyes with old glaucoma had been enucleated while they were severely inflamed but soft, we find a very great difference. Also in the choroid the emptiness of the large vessels is striking.

The retina and choroid showed the signs of highly developed typical retinitis pigmentosa with choroiditis; the greater portion of the vitreous was fluid, and contained numerous filiform opacities. All these changes were also found in the right eye which had been free from glaucoma.

The papilla had a cup-like excavation of the lamina cribrosa, the deepest part of which lay 0.90 mm. behind the posterior plane of the choroid.

5.

Glaucoma acutum. Death on the ninth day after iridectomy.

Theresa Klinger, 69 years old, was admitted to *v. Jaeger's* wards on March 26th, 1863, and an inward iridectomy was made on March 28th; she died on April 6th, 1863, of pneumonia. The history of the case is missing.

The sinus of the chamber is obliterated in the whole circumference, up to the margin of Descemet's membrane. The tissue of the agglutinated walls of the chamber exhibits only slight changes. The attached piece of iris is only a little thinner than the free portions of this membrane. The ligamentum pectinatum and *Fontana's* spaces deviate from the normal only by the presence of a few heaps of pigment. *Schlemm's* canal is everywhere of normal width, gaping, and perfectly empty. The attachment is very slight, and the parts can be separated by very little traction. We can, moreover, observe that no elements lie between the iris and the lateral and anterior walls of the chamber.

In the extent of the coloboma in which eleven processes are exposed, the iris is entirely absent, with the exception of a few remnants. But the lower limb of the coloboma lies in the corresponding angle of the wound, and, drawn out to a point, reaches nearly the plane of the conjunctiva. The folded lining of the ciliary muscle was detached from the muscle by the traction during the excision of the iris, and in some places it is drawn forward up to the margin of Descemet's membrane. In some sections, the detached processes appear agglutinated to the ligamentum pectinatum; in most sections no such attachment is observed. Although the iris is entirely separated from its former attachment to the canal of the wound, it yet curves in a loop around the peripheral lip of the wound, and shuts off the sinus from the rest of the chamber. The surfaces of the canal of the wound are nowhere in contact. The anterior wound lies directly opposite the margin of Descemet's membrane, the posterior 0.65 mm. before the latter. Some pale, spindle-shaped cells and numerous dark granules adhere to the surfaces of the wound.

Neither the iris, which has a thickness of 0.2 mm., nor the processes exhibit any anomalies of structure.

The ciliary muscle is in some places normal in form and size. There the meridional fascicles are thin, and the circular portion is uncommonly developed. But in the latter the connective-tissue elements have been developed at the expense of the muscular elements. In some places, especially in those in which iridectomy had been made, the thickness of the muscle has considerably decreased, and we cannot observe here that the circular predominate over the longitudinal fibres. The greatest thickness of the muscle varies in the different meridional sections between 0.65 and 0.40 mm.

No deviation from the normal appears in the choroid, apart from the extensive senile changes in the lamina elastica and the epithelial layer. (But I must here point out that the condition of the eye, which had lain in alcohol fourteen years, was unfavorable for a detailed examination.)

The papilla is the seat of a steep, total excavation, partly filled by connective tissue, the deepest part of which lies 0.45 mm. behind the choroidal surface. The nerve-fibres are atrophic in the highest degree.

The vitreous could not be examined.

6.

Glaucoma inflammatorium acutum. Iridectomy in a blind eye to relieve pain. Luxation of lens. Enucleation on account of continuation of pain.

Agnes Lenzer was admitted to *v. Jaeger's* wards on December 30th, 1876. Eight weeks previously, the diminution of sight had begun with inflammatory symptoms in the now amaurotic eye. On admission, there was dense corneal opacity, very wide pupil, very high tension, and severe pain. On December 30th, an inward iridectomy was made; on January 12th, 1877, the lens, which with its margin was pushed against the open wound, was removed through the enlarged wound of the iridectomy; and on January 20th, 1877, the eye was enucleated.

The synechia in the sinus of the chamber reaches up to the margin of Descemet's membrane. The agglutinated zone of iris is here and there a little thinned, but is generally not different from the free portions of the iris. The peripheral zone of the iris, therefore, as in the preceding case, loosely joins the anterior and lateral walls of the anterior chamber, without showing any remarkable changes of structure. The lamellæ of the scleral furrow are compressed; in their spaces lie a few red and white blood-corpuscles and clusters of pigment. The opening of *Schlemm's* canal is mostly slit-like, empty, in some meridional sections it cannot be seen. The strong filling of the scleral vessels near the empty *Schlemm's* canal is remarkable.

In the coloboma, the short stump of iris is firmly pressed against the corresponding parts of the anterior wall of the chamber *wound*. The canal of the wound ends on the anterior surface of the external tunic 0.5 mm. backwards from the margin of *Bowman's* membrane, on the posterior 0.25 mm. before the margin of Descemet's membrane. Both surfaces of the canal are widely separated from each other; the largest distance is 1.25 mm., and between them enters in front the strongly infiltrated and vascularized subconjunctival tissue, behind the short stump of iris and the lens capsule. In the middle of the canal we see only closely packed pus corpuscles.

The iris has a thickness of 0.775 mm.

The ciliary muscle is highly atrophic. The muscle-bundles are equally thinned in all its portions. Its greatest thickness is 0.45 mm. The processes are normal in structure and supply of blood. Their crests are uncommonly high and much folded, but neither attached to each other nor to the posterior surface of the iris. In the extent of the coloboma, the whole ciliary body has been drawn forward.

The choroid is somewhat thinner than normal. The vessels are well filled.

In the retina slight atrophy of the layer of nerve-fibres. The papilla shows a total, steep excavation of the lamina cribrosa, the bottom of which lies 0.25 mm. behind the level of the anterior surface of the choroid. But this hole is occupied by the remnant of the nerve-fibres and connective tissue in such a manner that only a partial excavation of the papilla exists. The latter is funnel-shaped and touches the margin of the papilla only on one side, thus resembling somewhat a physiological excavation. In this case we would by the ophthalmoscope alone probably not have arrived at a certain conclusion in regard to the character of this excavation. I think a physiological excavation has preexisted, the total excavation of the lamina cribrosa has then been brought about by the glaucomatous process, and the funnel-shaped excavation of the papilla has been enlarged by compression and atrophy of the nerve-fibres.

The vitreous body could not be examined in this case.

7.

Glaucoma inflammatorium acutum. Blindness during the first attack. Six years later (July 8th, 1876), *on account of slight pain and continued pathological tension, sclerotomy with following iridocyclitis and increase of the glaucomatous symptoms. The latter were allayed by subsequent iridectomy (September 25th,* 1876), *but cyclitis and severe pain continued. Enucleation (October 18th,* 1876).

Marcus Bledy, 66 years old (cf. first article).

The diameters of the eyeball, measured immediately after the enucleation, were as follows : the antero-posterior and transverse, 23.4 mm. ; the vertical, 23.1 mm.

The anterior surface of the iris is agglutinated to the lateral and anterior walls of the chamber. On the latter, the attachment reaches 0.45 to 0.5 mm. beyond the margin of Descemet's membrane. The adherent piece of iris has the same thickness as the free portion. The lamellæ of the scleral furrow are firmly compressed ; between them, and also in the peripheral zone of the iris and between the agglutinated walls of the chamber, lie a small number of red blood-corpuscles and collections of pigment. The calibre of *Schlemm's* canal is completely obliterated. In its place there are five to six blood-vessels, perfectly round on section and gorged with blood. On separating the lamellæ of the scleral furrow, it becomes manifest that those vessels are not identical with the section of *Schlemm's* canal, but that the latter has only disappeared because its walls touched each other, and that those vessels lie in front of and a little backwards from *Schlemm's* canal. In a number of sections near the coloboma, the attached walls of the chamber are perfectly separated, the iris being so far drawn forward that its insertion lies nearly behind the margin of Descemet's membrane. In a number of sections near the sclerotomy, the junction between iris and the cornea is changed in a peculiar manner. There Descemet's membrane is detached from the proper substance of the cornea, and adheres to the iris. The space between the proper substance of the cornea and the anterior surface of Descemet's membrane is densely filled with pus-cells. Posteriorly, the infiltration extends into *Fontana's* spaces and the ciliary body (cf. Fig. 5). This peculiar abscess has a length of 0.65 mm., and its greatest thickness is 0.25 mm. During the operation the iris was pierced, and this accident probably caused the detachment of the membrana Descemetii, which was formerly attached to the iris, and also the severe symptoms which followed the sclerotomy.

At the coloboma there remains a very short stump of iris; it is drawn toward and retained in the posterior wound, the original synechia has, therefore, been separated, and the stump of iris so placed that the free communication between the chamber and *Fontana's* spaces is interrupted. In meridional sections it surrounds the portion of the anterior chamber posteriorly from the wound like a loop.

At the posterior wound of the sclerotomy, the attachment of the iris to the cornea is much more intimate than anywhere else. Here also the iris is densely pervaded by an exudation which extends both forwards and backwards. Here the iris is also changed in its form, and contains large collections of black pigment. The anterior wound of the sclerotomy lies 1.1 mm. backward from the margin of *Bowman's* membrane. The cicatrix of the posterior wound is backwards from the margin of Descemet's membrane, between the latter and *Schlemm's* canal. The inner wound forms a shallow depression, into which the corresponding piece of iris is pressed like a cone (cf. Fig. 3). The canal of the wound has a length of 1 mm., and is firmly closed throughout its whole length. The very small callous substance is recognizable by its greater density, spindle-shaped cells, and a few granules of pigment. The nearer the surface of the globe, the smaller is the quantity of the intercalated substance. If the posterior wound had been, as usual, at least 0.5 mm. from the margin of Descemet's membrane, nothing would have been changed by the sclerotomy in the sinus of the chamber. Since the section had intentionally been located so peripherally in order to secure a good result, the knife had to pass through the tissue of the iris before its point could reach the aqueous humor. This was probably a further cause of the unfavorable consequences of the operation.

The anterior wound of the iridectomy lies 0.5 mm. posteriorly from the margin of *Bowman's* membrane. The subconjunctival and conjunctival tissue above it are very much vascularized and infiltrated with pus-cells. From there the cellular infiltration extends into the callus. The cicatrix of the posterior wound lies 1.1 mm. from Descemet's membrane. Both lips of the wound are nowhere in contact, but are kept 0.2 mm. asunder by the interposed infiltrated stump of iris. From here the infiltration passes into the canal of the wound. In the latter, the surfaces of the wound do not touch each other; between them lies a new-formed infiltrated tissue derived from the conjunctiva on the one side and from the iris on the other. The intercalated substance measures 0.2–0.3 mm.

The iris has an average thickness of 0.15 mm. The pupil and coloboma are perfectly closed by a membrane.

The ciliary processes are swollen and project behind the iris toward the axis of the eye; the folds are attached to one another, in some places also the elevations of the processes are agglutinated to the iris. The pigment which covers the processes is in some places accumulated into irregular heaps, in others it is missing; the ciliary body and iris are traversed by dilated blood-vessels and more or less infiltrated. At the place corresponding to the coloboma, the whole ciliary body is drawn considerably toward the axis of the eye; the ciliary muscle has retained its triangular shape; its inner margin, however, is not parallel to the axis of the eye, but almost vertical to it, and the anterior inner angle of the muscle is situated a short distance in front of the margin of Descemet's membrane. The layers of the ciliary muscle are very much thinned. The largest thickness of the muscle is in most sections 0.5 mm. In some sections it is 0.6 mm.; in these the atrophy of the muscular substance is greatest, but a partial compensation by new-formed connective tissue has taken place.

In the choroid behind the ora serrata the relations are normal.

In the retina, numerous superficial extravasations of blood; the walls of the retinal vessels much thickened, the layers of nerve-fibres and ganglion-cells atrophic. The papilla has a total cuplike excavation of the lamina cribrosa, the deepest portion of which lies 0.75 mm. behind the anterior surface of the choroid. The margin of the excavation is very sharp, and the layer of nerve-fibres at that point passes over it, enormously thinned. The optic nerve had by the atrophy of its nerve-fibres become so thin that in longitudinal sections the enlarged vaginal space measures on each side of the nerve one-third of the diameter of the optic nerve.

The vitreous body is macroscopically and microscopially perfectly normal.

8.

Glaucoma inflammatorium chronicum. Purulent inflammation of the cornea and uveal tract.

Juda Adler, 60 years old, was admitted to *v. Jaeger's* clinic on February 6th, 1877. Four years previously, incipient glaucoma of the right eye had been diagnosticated. For six weeks it has been perfectly blind. A large ulcer occupying the inner half of the cornea, pupil very wide, moderate hypopyon, tension diminished, severe pain. Enucleation on February 8th, 1877.

The anterior surface of the iris firmly attached throughout its circumference to the anterior wall of the chamber up to the margin of Descemet's membrane. At the scleral furrow, there was a depression into which the iris had been drawn. The whole scleral furrow was filled with pus-corpuscles. It is remarkable that the synechia had neither been separated nor increased by the suppuration. The hypopyon was wedged into the angle between iris and Descemet's membrane. The calibre of *Schlemm's* canal nowhere visible; in the sclera, sections of densely filled vessels.

All the tissues of the eye, from the cornea to the opticus (sclera and lens excepted), highly vascularized and infiltrated with pus and blood.

The ciliary muscle was atrophic in the highest degree. The largest thickness of the infiltrated muscle was 0.6 mm., but it contained only a few thin muscular lamellæ. The anterior inner angle of the muscle was absent; at the corresponding margin it was obliquely truncated.

The bottom of the excavation lay 0.25 mm. behind the level of the inner choroidal plane, and was probably elevated by the strong infiltration of the optic nerve in and behind the lamina cribrosa.

9 AND 10.

Glaucoma absolutum oc. utr.

Alois Forstner, 59 years old, died on April 5th, 1866, perfectly blind in both eyes by glaucoma. Unfortunately, I could learn nothing about the history of the case.

Left Eye.—The peripheral circular synechia is distinctly visible with the naked eye, it does nowhere extend beyond the margin of Descemet's membrane. The agglutinated piece of iris is very thin, and in some places only the uveal layer has been preserved. The cavernous tissue of the scleral channel is moderately infiltrated with pus-cells. The calibre of *Schlemm's* canal is almost everywhere gaping and of normal size; in a few sections it is invisible.

The iris has a thickness of 0.25 mm., is moderately infiltrated with pus-cells. The pupil perfectly closed by a membrane. Also the folds of the processes behind the iris are moderately infiltrated and somewhat atrophic. The ciliary muscle is highly atrophic; in meridional sections it has the form of a spindle. Only traces of its most anterior meridional bundles have remained, and its greatest thickness is 0.3 mm.

In the choroid, numerous excrescences of the lamina elastica are seen. In the capillaries of the choroid, a surprisingly large number of white blood-corpuscles; outside of the capillaries, none at all.

The papilla shows a total, steep excavation of the lamina cribrosa with a wavy bottom; its depth varies in the same longitudinal section between 0.45 and 0.65 mm.

Right Eye.—The peripheral circular synechia reaches only a trifle beyond the margin of Descemet's membrane. In the agglutinated piece of iris only the uvea has been left. Seen from behind, a shallow groove, 0.45 mm. in width, runs between the apices of the ciliary processes and the free disc of the iris. From the complete atrophy of the iris-tissue in the synechia, it seems as if the iris were cut obliquely, and originated abruptly from the margin of Descemet's membrane. The tissue of the scleral channel is moderately infiltrated with white and red blood-corpuscles and heaps of pigment. The opening of *Schlemm's* canal is gaping and empty in most of the sections, in others it cannot be distinctly recognized.

The iris is 0.2 mm. thick, moderately infiltrated with pus-cells. The stellate cells of the iris are mostly unpigmented; but many free granules and collections of pigment lie in the tissue of the iris.

The ciliary body is atrophic to a high degree. Its greatest thickness is 0.3 mm. Only a few remnants of the meridional fibres of the muscle are left.

The choroid presents no striking features, it is much thinner than normal, and is more easily and smoothly detached from the sclera, for the superachoroidea has almost entirely disappeared. No traces of inflammatory changes, new formations, or infiltration.

The papilla is the seat of a total steep excavation of the lamina cribrosa, the greater portion of which is filled by a very delicate fibrillar tissue; and the deepest point of the lamina lies 0.7 mm. behind the anterior plane of the choroid.

II.

Glaucoma with staphyloma posticum and choroiditis exsudativa.

Anna Ziegler, 87 years of age, died on June 9th, 1874. The existence of glaucoma in the left eye of this person was only noticed at the anatomical examination. The history of the eye during life remained unknown.

The measurement of the globe, fourteen hours after death, revealed: antero-posterior and transverse diameter, 24.9 mm.; vertical, 21.9 mm.

The conditions of the sinus of the chamber and of the ciliary muscle are of the same same kind as in the last case, but more developed. The attachment of the iris extends 0.25 mm. beyond the margin of Descemet's membrane. The width of the groove between the free portion of iris and the remnants of the ciliary body varies between 0.65 and 1.10 mm. The lamellæ of the scleral furrrow contain in their spaces large clusters of pigment; the calibre of *Schlemm's* canal is mostly gaping, empty, surrounded by collections of pigment, but cannot be recognized in some sections.

The iris has a thickness of 0.2 mm., contains more white blood-corpuscles than normally, and seems to have its origin at the membrana Descemetii.

The small remnants of the ciliary processes lie in some sections directly upon the posterior surface of the sclera, the ciliary muscle having completely disappeared, in other sections a few meridional fibres are preserved.

The choroid shows the changes of exsudative choroiditis with following atrophy, as we find it frequently in posterior staphyloma. The atrophic retina, which in many places is attached to the choroid, has been invaded by a considerable quantity of pigment, which lies especially around the vessels, often enveloping them like sheaths. The vitreous humor entirely fluid. The papilla excavated.

12.

Secondary glaucoma with enlargement of the whole eyeball.

Johanna Hohler, 26 years old, was admitted to *v. Jaeger's* clinic on October 6th, 1877. When she was four years old, her right eye was struck by a fragment of bone. She states that, a very short time after the injury, the eyeball began to enlarge, but only two years after the accident she became perfectly blind. The patient cannot tell with any certainly whether the eye is still increasing in size, but she is positive in her assertion that size and tension of the eye are very often subject to striking changes. The larger inner half of the cornea is replaced by cicatricial tissue, the outer half of the cornea is transparent, but, like the cicatricial portion, much enlarged. The iris is united to the leucoma, but corresponding to the transparent portion of the cornea, there is an enormously deep chamber and tremulous iris, with a free pupillary margin. Some light is reflected through the pupil, but no details are discerned. Amaurosis, enucleation on Oct. 9th, 1877.

The measurements, taken immediately after the enucleation, showed: antero-posterior diameter, 34.2 mm.; transverse, 28.5 mm.; vertical, 28 mm.; transverse diameter of cornea, 20 mm.; vertical, 19 mm.; distance of vertex of cornea from base, 9 mm.

In the extent of the cicatrix the iris is highly atrophic and almost everywhere adherent to, or impacted in the cicatrix. Corresponding to the transparent portion of the cornea, only the peripheral zone of iris is agglutinated to the anterior wall of the chamber and atrophied, with the exception of the uveal layer. Since the whole cornea, and therefore also the portion between the insertion of the ciliary muscle and the margin of Descemet's membrane, to which the iris is attached, are enormously distended, the groove between the ciliary muscle and the apparent origin of the iris at the cornea (as in cases 10 and 11) is also very wide. In some places it measures 1.15 mm. The lamellæ of the scleral channel are very much stretched, indistinctly visible, and between them lie large heaps of pigment. The calibre of *Schlemm's* canal has entirely disappeared.

The free portion of the iris has a thickness of 0.1 mm.

The uveal tract shows no other changes but mechanical thinning of the membranes, stretching of the vessels, enlargement of the capillary meshes, separation of the cellular elements. In the iris I find in some places small collections of lymphoid elements; in the processes and the choroid, there are no traces of inflammatory changes.

The ciliary body exhibits a relatively large-sized muscle which has changed its form considerably, is very much lengthened, and its posterior inner angle displaced far backwards. The muscle bundles are stretched, but do not appear thinner than can be accounted for by the stretching. The greatest thickness of the muscle is 0.5 mm. Between the muscular layers there is very little connective tissue. The vessels of the choroid are empty.

The retina has degenerated in its anterior layers into a connective tissue network with enormously thickened walls of the blood-vessels. The excavation of the lamina cribrosa has a depth of 1.0 mm. The vitreous body was replaced by a serous clear fluid, and only in the anterior segment of the globe some vitreous of normal consistency was present. The lens had become an irregularly shaped flat disc.

13.

Secondary glaucoma with total cicatricial staphyloma of the cornea.

Peter Linzerboth, 66 years old.

The description of the anterior segment of the eyeball has been given in the first article. There I stated that a small number of round cells were found in the connective tissue of the ciliary muscle, that the meridional bundles of the muscle had a very straight course, and that the circular fibres were very scanty. At the time of the severe inflammation in the anterior segment of the eye, the ciliary muscle had certainly been also affected in a high degree, and it had later been distended by the formation of the staphyloma. By these circumstances I explained the changes in the muscle at that time, when I had not yet made anatomical examinations of the eye with primary glaucoma. But now I must remark that, perhaps, also the glaucoma has participated in bringing about these changes. The atrophy of the muscular bundles is much less marked than in all the cases above described (except 12), and the part which the inflammation and formation of the staphyloma have taken in the atrophy cannot be determined. In this case, therefore, I must leave it undecided whether the glaucoma has changed the muscle, and eventually to what extent it has been done. In many meridional sections the inner and anterior sides formed an obtuse angle. The greatest thickness of the muscle is 0.55 to 0.60 mm., and between its bundles we find an unusually large mass of connective tissue.

In the choroid almost everywhere isolated pus-corpuscles are found; in but a few places they are accumulated in large clusters.

The excavation is total, steep, cup-like, and filled to a great extent by loose delicate fibres. The deepest point of the lamina cribrosa lies 0.875 mm. behind the anterior plane of the choroid.

14.

Inward iridectomy for leucoma adhærens. Healing normal. Death of patient two years after the operation.

Alois Brandeker, 26 years old (cf. first article 1).

The cicatrix of the anterior wound is 0.55 mm. posterior to Bowman's membrane; the sclera shows at this place no change of its level at all. The posterior wound lies 1.0 mm. before the margin of Descemet's membrane. The cut ends of this membrane are placed one above the other. The length of the canal of the wound is 1.08 mm. The cicatrix is marked in stained preparations by the intense uniform redness, and the lymph-spaces, which are very frequent in the adjoining corneal tissue, are here entirely absent. Near the cicatrix all the divided lamellæ of the cornea bend with their peripheral ends towards the posterior surface of the cornea, and with the central ends towards the anterior surface. We see the corneal corpuscles rising above their normal planes, and following almost the direction of the cicatrix. In the cicatrix, the cells are more closely arranged and irregularly distributed. Here they are also formed more regularly, and frequently contain pigment granules. In the short space of the scleral wound the course of the scar is less distinct. The callus is 0.09 mm. broad; in many sections there is so little of it, that between the ends of the fibres we observe only a single row of cells in the canal of the wound.

Near the processes the coloboma is 4.5 mm. broad. The length of the remaining stump of iris is 0.54 mm., and the distance of the free margin of the stump from the posterior wound is 1.32 mm. Before the iridectomy, the sinus of the chamber was obliterated; the iridectomy tore the synechia between iris and cornea, and the surface of the iris remained free.

15.

Upward-inward iridectomy for leucoma adhærens. Healing of wound tardy. Hemorrhage into the anterior chamber two days, death seven days after the operation.

Josef Peibel, 56 years old (cf. first article 2).

The anterior wound is 0.9 mm. posterior to the margin of *Bowman's* membrane; the posterior 0.5 mm. from the margin of Descemet's membrane; the canal of the wound measures 1.2 mm. in length. An attachment throughout the whole length of the canal does not exist yet in any of the meridional sections, but in many of the latter the walls are partially united. Upon the surfaces of the wound lie a few very pale spindle-shaped cells with granulated oblong nuclei, blood-corpuscles, and clusters of pigment. The cut ends of the fibres are slightly curved, and between them project large, spindle-shaped cells, the processes of which we see in some places still partly between the corneal fibres, but partly already in the direction of the wound. Upon the central lip of the posterior wound, between Descemet's membrane and the corneal substance, there is a distinct heap of these new-formed cells.

The iris is completely cut out, though before the iridectomy an adhesion existed between the iris and the wall of the anterior chamber. The ciliary processes are drawn toward the wound.

16 AND 17.

In both eyes of a man who died on October 31st, 1875, iridectomies were found. Since I could not learn anything about the history of these eyes, I only give a few short notes in regard to the scars resulting from the operation. The cicatrix of the anterior wound lies, in the right eye, 0.6 mm., in the left, 1.3 mm. posteriorly to the margin of Bowman's membrane; the cicatrix of the posterior wound is in the right 0.9, in the left, 0.35 before the margin of Descemet's membrane. The length of the canal in the right, 1.3 mm. (0.4 mm. of which between scleral fibres); in the left, 1.4 mm. (0.5 mm. of which between scleral fibres). The iris has been perfectly exsected in both. The condition of the scars is entirely similar to that described in case 14.

In conclusion, I discharge a very agreeable duty in expressing my warmest thanks to my sincerely adored teacher, Prof. *Ed. v. Jaeger*, to whose liberality I owe the greater part of the clinical and anatomical material upon which this paper is based.

MARCH, 1878.

EXPLANATION OF THE PLATES.

FIGS. 1 and 2 present the surface synechia in the periphery of the anterior chamber from the eye of *Anna Prösselmeyer* (case 3) before and after the iridectomy. C. S., Canalis Schlemmii; M. B., Membrana Bowmani; M. D., Membrana Descemetii.

FIG. 3. Section through the cicatrix after sclerotomy; canal of wound entirely in the sclera; *Marcus Bledy* (case 7). A. M., Insertion of tendon of ciliary muscle.

FIG. 4. Section through a cicatrix of four weeks' duration, from a penetrating wound in the sclerotic of an albinotic rabbit. Scl., Lips of scleral wound separated by new-formed tissue.

FIG. 5. Abscess between cornea and Descemet's membrane from the eye of *Marcus Bledy* (case 7).

THE REMOVAL OF FOREIGN BODIES FROM THE INTERIOR OF THE EYE.

By H. KNAPP.

In the year 1862, shortly after the opening of the "Ophthalmic Clinic" at Heidelberg, Prof. Esmarch honored me and the institution with a visit.

Case I.*—*Piece of steel in lens removed with probe bent in the shape of a hook.*

Among the patients there was one whose cornea had been pierced, several days before, by a little piece of steel, which had been arrested in the crystalline lens, quite close to the inner pupillary edge. The eye being greatly irritated, the lens swollen and, of course, opaque, I thought it necessary to remove the foreign body, one corner of which could just be seen at the edge of the iris. I made a large corneal section, and tried several times to seize and extract the foreign body by means of forceps, but always failed, then Esmarch asked me, "Will you not try a curette?" "There is none at hand," I replied. "Then let's make one," said he, and taking a Bowman's probe, he bent its end and handed it to me. I passed the curved end behind the foreign body, which I drew without difficulty into the corneal wound, where it was easily seized and extracted with a pair of anatomical forceps.

Then I removed as much cataractous substance as could be evacuated by depression of the posterior lip of the wound and gentle counter-pressure on the outer surface of the cornea.

The wound healed, and, by a subsequent iridectomy, with which also a small piece of the pupillary pseudo-membrane was removed, the eye acquired tolerably good vision.

Prof. Esmarch, in the pursuit of his great and beneficial objects, the accomplishment of which has added so much glory to his name, has, no doubt, long since forgotten the little scene of the foreign body in the lens, but his advice, the appropriateness of which he demonstrated to me *ad oculum*, had deeply impressed me, and whenever afterward I had to deal with the removal of a foreign body from the eye, I used the curette by preference, and in some cases obtained with it the most fortunate results.

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* Note.—All the cases interwoven in this paper that are printed in small type and marked with successive numbers have occurred in my own practice, whereas those cited from literature are printed in the type of the context.

Surgeons have known for a long time that, in the removal of foreign bodies from narrow canals and cavities, curette-shaped instruments are very appropriate, but in ophthalmic practice they seem to be less extensively used than they ought to be. This statement I base on repeated evidence obtained in my travels, and beg to present only two corroborating examples.

In the year 1868, I visited one of the most celebrated ophthalmic clinics of the European continent, the surgeon of which is one of the most esteemed operators. In the hospital I saw a case the very counterpart of the one described above. A little piece of stone had pierced the cornea, and lodged, visible, in the opaque and swollen lens. The operator made several unsuccessful attempts to extract the foreign body with toothed and anatomical forceps. At last he succeeded by means of a spoon. The witnessing of these attempts affected me unpleasantly, and I would fain have reminded the operator of the value of the curette, but being the younger man, and for reasons of etiquette, I refrained. When I saw the eye again it was a ruin.

Not long after this, in one of the London ophthalmic hospitals, I saw a patient in whose iris a little piece of iron was imbedded. When the surgeon, with whom I was upon very friendly terms, had made several unsuccessful attempts to seize the foreign body with forceps, pushing it the more deeply into the iris, I suggested to him to use a curette, which advice he gladly followed and extracted the piece of iron without difficulty.

After these introductory remarks, I may be permitted to proceed to a comprehensive compilation of the results of my own experience, supplemented by a critical consideration of the literature of the subject, as far as it was accessible to me.

A.—FOREIGN BODIES IN THE ANTERIOR CHAMBER.

Foreign bodies are met with in all the walls of the anterior chamber, but I have never seen them suspended in the aqueous humor.

1. *Foreign Bodies in the Cornea projecting into the Anterior Chamber.*

From my own experience I remember only two such cases.

Case II.—*Small piece of stone impacted in the cornea and projecting into the anterior chamber, pushed back with forceps and removed.*

The first (which I copy from my Heidelberg case book) relates to a working man, Caspar Schmidt, æt. 56, of Dossenheim near Heidelberg, who was admitted to the clinic June 26th, 1866.

A small, triangular piece of stone lodged with its base in the cornea, and projected, with point directed obliquely upward, into the anterior chamber. It could not be seized from without. I therefore made with the lance-knife an incision in the upper part of the cornea, introduced a pair of anatomical forceps, seized the little stone at its apex, and tried to draw it out through the anterior chamber. But the foreign body not yielding to the traction, I pressed it back against the cornea until its base projected so far that it could be seized and extracted with forceps. The canal of the wound, appearing unclean, was enlarged and freed of all adherent particles of sand. In the evening I found the iris adherent to the place of perforation, the pupil wide, and in the centre of the anterior capsule a circumscribed white opacity.

June 27th.—No reaction; no synechia; the opacity on the lens capsule had disappeared.

June 28th.—Cornea in the tract of wound opaque, everywhere else clear; no anterior synechia left; all vascular irritation had disappeared. Patient was discharged cured.

Case III.—*Small piece of steel projecting through the cornea into the anterior chamber removed with hook.*

In the other case, a needle-shaped piece of steel had entered the cornea in its outer and lower quadrant, 1½‴ below its centre; one end of it remaining impacted in the cornea, the other projecting from 1‴ to 1½‴ obliquely inward and slightly upward into the anterior chamber.

The patient was a young workman in an engine shop of New York, and the injury had happened only a few hours before he came to me.

The anterior chamber was filled; the pupil regularly round and movable; the sight good; no opacity of the cornea, but lachrymation and moderate conjunctival injection. The outer end of the foreign body appearing to be near the posterior surface of the cornea, I made no attempt to remove the foreign body in the usual way, being afraid of pushing it entirely into the anterior chamber, where it would have fallen either on the iris or into the sinus between iris and cornea, and from where its removal would have been much more difficult. I therefore made, with a Beer's cataract-knife, a small corneal incision 1½'''–2''' below the foreign body, letting the aqueous slowly escape. Then I introduced a broad hook from the outer side over the superior edge of the foreign body, and extracted it at the first attempt. The iris had not protruded, and the pupil remained round. I instilled atropine and applied the ordinary bandage. In a few days the eye recovered with entire preservation of sight and without synechia.

From personal intercourse with other oculists, I have received the impresssion that curette-like instruments are hardly, if at all, used for the extraction of foreign bodies from within the eye, but in literature I find them repeatedly mentioned. In Mackenzie's treatise,* two observations are recorded which are similar to the one just related, and in which Mackenzie had employed a blunt hook.

In the first case, a small piece of metal had struck the eye of a workman, and twelve days later Mackenzie noticed a splinter of brass, 1½''' in length, on the inner face of the cornea. No lesion of the cornea was visible as yet, but there was considerable iritis, which Mackenzie in part subdued by belladonna and antiphlogistic treatment. He then made with a Beer's cataract knife a corneal incision 2½''' to 3''' in length, and 1½''' above the transparent edge of the cornea, leaving the blade of the knife in the eye until the aqueous had partially escaped, thus preventing prolapse of the iris. He then introduced a small hook, drew the splinter over the inner surface of the cornea into the wound, where it was easily extracted. Perfect recovery.

In the second case, a thorn rested with the thicker end in the cornea, with its thinner in the iris; the injury occurred three weeks previously; the corneal wound was closed, and the eye showed but moderate irritation. Mackenzie opened the anterior chamber at its temporal edge, the thorn being situated near the nasal edge. With a Schlagintweit's hook he was unable to detach it from the cornea. During the attempt to extract it, the iris was torn and the eye filled with blood.

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* Cases 247 and 248, p. 394, 4th London Ed.

Nothing else is mentioned of the patient, and it is not unfair to presume that his eye was lost.

In the first case of Mackenzie, the foreign body rested only in the cornea, and projected obliquely into the chamber; in the second, it rested in the cornea and the iris, that is, both in the anterior and posterior walls of the anterior chamber. This case reminds us of the necessity of caution, dwelt upon by different authors, as to the danger of wounding iris and lens, during attempts at removal of foreign bodies lodged with one end in the cornea, while the other projects free in the anterior chamber. Zehender says, in his text-book of ophthalmology:* "To avoid this danger, Agnew† thrust a Beer's cataract knife on one side of the foreign body into the cornea, and caused it to emerge on the other, so that the projecting point of the foreign body was opposed to the blade of the knife, which afforded the foreign body a firm support, thus obviating the danger of the foreign body falling into the anterior chamber during its removal in the ordinary way. I have, under similar conditions, thrust a broad discission needle at the proper place into the cornea, and with its surface pushed the projecting point from within outward, whereby the foreign body fell almost by itself out of the hole which it had bored. In a similar manner George Lawson has operated in similar cases."

The two cases reported by Lawson are instructive.‡ In the first, a chip of metal, 1½ lines in length, lodged deeply in the cornea, and projected so far into the anterior chamber that it seemed almost to touch the lens. Its outer end could be felt with a probe under the epithelium. It could not be seized from without. Dr. L., therefore, introduced a broad needle into the anterior chamber, pressed with its broad surface the chip of iron back toward the cornea, where an assistant seized and extracted it. "The splinter of metal must have injured the lens, since the lens was cataractous."

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* 3d Ed., 1876, vol. 2, p. 588.

† New York Medical Record, Vol. I., p. 251, 1866. "A Method for Removing a Foreign Particle from the Cornea." Dr. C. R. Agnew kindly informs me that since the above publication he has several times successfully employed the same method.

‡ London Ophth. Hosp. Rep., pp. 36 to 38, 1867.

The second case resembled the first; the foreign body, however, was a thorn which bent when Lawson attempted to press it back with the surface of a broad needle introduced into the anterior chamber. L. therefore enlarged the corneal wound made by the needle, seized the thorn at its point in the anterior chamber, and drew it out. In doing this, the iris was injured, and consequently the piece involved drawn out and cut off. Recovery with preservation of sight.

The introduction of a broad needle, or of a cataract knife, into the anterior chamber has a double object.

1st. To protect the iris and lens during the different manipulations for the removal of foreign bodies. This is very important, and should never be omitted when foreign bodies project into the anterior chamber. I would recommend that the surface of the instrument be held obliquely, so that the foreign body could not fall into the sinus of the chamber.

2d. By pressure from behind to push the foreign body out again.

This can, of course, only be accomplished if the foreign body is hard and almost perpendicularly placed in the cornea.

A broad needle, one surface of which is slightly hollow, might be used with greater advantage, the foreign body being less likely to slide away from it. This device to protect the iris and lens and preventing a foreign body from falling into the anterior chamber, seems to be tolerably well known, since it is mentioned in several text-books. R. B. Carter says that it was originated several years ago by Dixon (opening of the cornea near its periphery with a broad needle, introduction of a blunt spatula behind the foreign body). Arlt, in his excellent treatise "On the Injuries of the Eye and their Medico-legal Aspect,"* says that he has introduced a Daviel's spoon through a lateral corneal opening behind the body in the anterior chamber, and either pressed it back or at least so steadied it that he could safely seize it. Desmarres† alleges that he has devised a procedure which in many cases did him good service. He passes his paracentesis needle behind the foreign body, keeps it gently pressed against the cornea so that no aqueous can escape, then cuts with a cataract knife through the corneal tissue along and in front of the foreign body, prying the latter out as soon as it has become loose. These last-mentioned procedures are less to be recommended than that of the cataract-knife and the broad needle.

II. *Foreign Bodies upon and in the Lens.*

Of foreign bodies lying upon the lens, that is, on the capsule in the pupillary space, I know only one example ; it refers to a case in my own practice. I may, therefore, be permitted to report it here exactly according to the notes in my case-book made at the time.

CASE IV.—*Chip of iron on the anterior capsule ; successfully removed with forceps.*

George Merckert, æt. 40, of Ingenheim near Landau, presented himself on June 25th, 1867, in my clinic at Heidelberg, with the following history : Sixteen years previously, a small piece of iron struck his left eye. After the irritation immediately following it had passed, the eye remained healthy until Nov., 1866, when, one day, something flew into his eye again, "but the affair didn't amount to anything." Since Feb., 1867, the eye has been painful and red. *Condition upon admission :* Marked circumcorneal injection ; photophobia ; iris swollen, dull ; upper and inner part of pupil irregular ; pupillary area plugged with a gauze-like pseudo-membrane, which projected conspicuously into the anterior chamber. Aqueous very turbid, slight hypopyon. The scar of the previous injury still visible in the cornea.

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* Wiener Med. Wochenschrift, 1874, translated into English by Charles S. Turnbull, M.D., Phila., 1878.

† Traité des Maladies des Yeux, Vol. II., p. 312, 2d. éd., 1855.

Patient had eight leeches applied to the temple, atropine instilled every half-hour, and mercurial ointment rubbed into the skin of the limbs. In four days, the inflammation was so far subdued that I could venture to remove the foreign body which had become visible in the pseudo-membrane. I made a corneal section with the lance-shaped knife and drew a chip of iron, together with the membrane enveloping it, out of the eye. Copious hemorrhage into the anterior chamber ensued, but was absorbed in two days. The inflammatory symptoms soon subsided. An opacity remained on the capsule where the foreign body had rested. Eleven days after the operation, the patient was discharged cured, and in the enjoyment of good sight.

It is not entirely clear, from the history of this case, whether the foreign body had lain in the eye sixteen years or six months, for the patient mentions two injuries ; but the former, longer interval seems much more probable, since the patient remembered the first accident very well, and furthermore alleged that the second had been a trivial matter ; moreover, inflammation set in not immediately, but as late as four months thereafter.

In all probability, the second injury was only a foreign body on the cornea. The case is at any rate distinguished by the perforation of the cornea by a chip of iron which rested on the anterior capsule, produced plastic inflammation (iritis) encapsulating the foreign body, then disappearing, and afterward recurring with great intensity. I cannot suppose that the foreign body had opened the capsule of the lens and remained lodged in it ; for, in the description of the case, no opacity of the lens is mentioned, but only the opacity upon the capsule, and the discharge of the patient with good sight.

Cases of foreign bodies *in the lens* are not rare. If the foreign body is small and not in contact with the iris ; the consequence is usually only an insignificant or moderate and transitory irritation produced by swelling of the lens. If the opening in the capsule is small, it generally closes in a few days or weeks, and the foreign body may for years remain quiet in the opaque lens. The best thing to do is to abstain from operation until the inflammatory symptoms have passed and the cataract is mature. The extraction of the cataract can be performed when deemed most opportune.

CASE V.—*Chip of iron in lens producing cataract; successfully removed with the lens seven months later.*

In October, 1869, a man, æt. 39, came into the Dispensary of the New York Ophthalmic and Aural Institute, after a chip of iron had flown into his eye a few days before. There was moderate circumcorneal injection, a small closing wound a little below the centre of the cornea, the anterior chamber shallow, the pupil narrow, the iris discolored, the anterior capsule lacerated, and in the anterior cortex, near the inner edge of the pupil, a small, dark, foreign body, which I presumed to be a piece of iron, since the man had been hammering iron when the accident occurred. I ordered atropine instillations, leeches to the temple, and rest in a darkened room. In several days the pupil was wide, and the circumcorneal injection very slight. The wound in the capsule closed, the lens was cataractous, swollen for months, as a spontaneous cataract at this age is apt to be; then it shrank. Seven months after the injury, when the cataract was mature and no longer swollen, I extracted it in the usual manner with a good result (S. $\frac{20}{30}$). The chip of iron could be noticed in the lens during the maturing of the cataract, and also during its extraction. It came out with the cataract, and was hardly 1‴ long.*

CASE VI.—*Powder-grain in lens. Cataract. Removed with the lens by suction-instrument. Good result.*

In another case where I had to deal with a swollen cataract, in consequence of a powder-grain that had entered the eye of a young man and lodged in the lens, I made an incision of 1‴ to 1½‴ near the outer edge of the cornea, cut out a piece of iris, and removed the lens with a Bowman's suction instrument. The powder-grain was visible in the cataractous mass, and I could also notice its entrance into the orifice of the canula. The removal of the lens was not complete, plastic iritis ensued, and a subsequent division of the secondary cataract was required to clear the pupil.

I may be permitted here to remark that the suction method of soft cataracts, still practised at Moorfield's Hospital, has not given me so favorable results as the method by absorption, which, of course, requires more time. I have, therefore, not performed it any more during the last ten years. Even in soft cataracts inclosing small foreign bodies, I would not resort to it again, but prefer the modified linear extraction through a large corneal section. The foreign body, I think, will not fail to be liberated with the lens, if care be taken that the cataract can escape "en masse," which will be effected by holding the posterior lip down with a spoon, and pressing with another spoon or hard-rubber curette on the opposite periphery of the cornea, in the direction toward the centre of the globe. In this way the wound will be made to gap largely. If it should, nevertheless, happen that the foreign body remains somewhere in the anterior chamber, I would try to remove it with the grooved hook (see below).

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* This case is briefly recorded as No. 20 in the tabular statement of 200 cataract extractions, which I published in the sixth volume of these ARCHIVES, p. 320.

If larger foreign bodies produce a severe reaction or cause the lens to split in pieces, with which the foreign body is liable to fall into the anterior chamber, the lens and foreign body should be extracted without delay. In doing this, it is appropriate to make the corneal section large. If that portion of the lens which incloses the foreign body adheres to the capsule or iris, or if, on the other hand, the cataractous substance in which the foreign body is suspended is very soft, then there is danger that the foreign body remains in the eye, while the cataract is readily expelled. In such cases it is advisable first to remove the foreign body with a grooved hook or a pair of anatomical forceps, and then complete the extraction of the cataract. If the foreign body is lodged visibly in the posterior cortical layers, two methods of extraction may be found useful, of which Hulke and A. v. Graefe have furnished examples.

In Hulke's case* a splinter of iron had penetrated the periphery of the cornea and iris, and lay in the posterior cortical substance below the nucleus. Hulke introduced a cataract needle through the cornea and lens behind the foreign body, and pushed the foreign body into the anterior cortical substance. Then he made a corneal section, removed first the foreign body with a curette, and then the cataract. Recovery without irritation. Vision good.

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* Ophthalmic Hosp. Rep., I., No. 6.

In Graefe's case* a splinter of metal, about ⅔''' in length, lodged in the posterior cortex, opposite the outer edge of the dilated pupil. The accident had occurred 1½ weeks previously. A small corneal scar and a small rupture of the capsule were present. Graefe dilated the rupture with the needle. The lens swelled, the foreign body gradually moved forward, and, surrounded by lens matter, projected into the anterior chamber three weeks later. Lest it fall to the bottom of the chamber or adhere to the iris, Graefe made a linear section, passing the knife behind the protruding lens-substance. The foreign body and the protruding portion of the cataract came out as soon as the knife was withdrawn, and the remainder of the lens was then expelled in the usual manner. 1½ weeks later, perfect recovery.

Smaller foreign bodies which are surrounded by lens substance generally cause no irritative symptoms at all. They may be left in the eye undisturbed when the capsule has closed over them.

CASE VII.—*Chip of iron encapsulated in the lens. No reaction.*

To illustrate this, I will mention the case of a boy of five years of age, son of Mr. H. M., of Raleigh, N. C., who was brought to me in September, 1872, after a chip of iron had entered his eye three years previously. It had caused no inflammation, and when I examined the eye I found it normal in shape and tension, the crystalline lens so far absorbed that I recognized the fundus oculi through the upper and lateral parts of the pupil, while in the lower the foreign body was still discernible in a whitish substance. It was safely encapsulated.

The interior of the lens-capsule is, in fact, the only place in the eye to which an extraneous body may be intrusted for a length of time. And even this cannot be said without reserve, for some examples are known in which a foreign body, encapsulated and quiet for years, at once and without any assignable cause produced the most intense inflammation. The same observations have more frequently been made with extraneous bodies which had lain quietly encapsulated for shorter or longer periods in the retina or other parts of the eye. An example of the former condition is reported by Sämisch.* A small piece of basalt rock had lain quietly in the eye for twelve years, when iritis with cloudiness in the pupil and anterior chamber ensued. The foreign body was extracted from the secondary cataract. Recovery.

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* His Arch., II., 1, p. 229, and in extract by Zander and Geissler: Injuries of the Eye, p. 188.

It frequently happens that a foreign body enters through the cornea into the interior of the eye, and it is impossibe to determine its seat. A hole in the iris or the lens-capsule indicates that it penetrated into the lens, but we are unable to make out whether it remained in the lens or proceeded behind it. As soon as the presence of a defect in the upper part of the visual field reveals a corresponding detachment in the lower part of the retina, which foreign bodies sunk to the bottom of the vitreous chamber generally produce, the question in most cases is no longer as to the removal of the extraneous substance, but of the globe. During the first time, however, the visual field is complete and the inflammatory reaction slight, and as the opacified crystalline lens shuts off the posterior part of the eye, we are unable to track the foreign body further than to the lens. Whether it has been arrested there, or penetrated more deeply, the future will reveal. Intense inflammation and increase of tension of the globe setting in, may be occasioned by swelling of the lens, iritis, and consecutive glaucoma, or by beginning purulent choroiditis. In such cases the lens should at once be removed, but before the surgeon begins to operate, he should ask the patient or his relatives for discretionary power at once to enucleate the eyeball if, after the removal of the lens, the foreign body be not detected.

CASE VIII.—*Foreign body in retina; not found on extraction of lens; immediate enucleation of eyeball.*

Only a few weeks ago, a typical case of this kind came under my observation. A man, æt. 33, while hammering the hoop of a barrel, noticed that something struck his eye. A small piece at the edge of the hatchet was wanting, and the fresh surface showed that it had but recently been broken off. There was a small closed wound in the centre of the cornea and a corresponding rupture in the capsule. Cataract. Tn., F. complete, very moderate irritation. *Diagnosis:* foreign body in the lens or deeper. *Treatment:* antiphlogistic and expectative. On the ninth and tenth days, violent pain in the eye and head, loss of sleep and appetite. T2, F. complete, slight chemosis, œdema of lids.

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* Zeh. Klin. Mon., III., p. 46–51, 1865.

Probable Diagnosis.—Incipient purulent choroiditis, *i. e.*, panophthalmitis. Eserine reduced tension and pain for five hours.

Treatment.—The soft lens completely removed by linear extraction. No foreign body being found, immediate enucleation of the globe. When the eye was opened, a small piece of steel, one line in length, was found in an isolated pustule at the posterior part of the fundus, near the optic nerve. Excepting the above-mentioned pustule and marked venous congestion of the retina, nothing abnormal was found in the posterior part of the eye.

If the foreign body, which can be seen in the lens, remains in the eye after the extraction of the cataract, a large iridectomy should be made, and the foreign body sought for and extracted with the grooved hook, as C. S. Jeaffreson did in one case with complete success.*

III. *Foreign Bodies upon and in the Iris.*

Several very interesting cases of this kind, taken from the literature up to 1863, have been compiled by Zander and Geisler.† The examples of spontaneous *expulsion* through the cornea,‡ or *absorption* (in particular, of broken points of cataract needles) and *encapsulation* of foreign bodies with preservation of good sight are so exceptional that they can hardly influence our treatment.

In all cases in which the seat of the foreign body can be ascertained upon or in the iris, we should remove the foreign body either with or without iridectomy. If it lies loosely upon the iris, it may, after the corneal section, escape with the aqueous; some examples of this kind are reported. But even while keeping this fortunate occurrence in mind, we should always arrange the operative procedure in such a way as to admit of a sure and gentle removal of the foreign body by instruments.

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* See his instructive article on Foreign Bodies Lodged in the Eye, Medical Times and Gazette, March 28th, 1874, page 342, case 7.

† Page 160, etc.

‡ Dixon, Dublin Quarterly Journal, page 210, 1848.

In making this section, a Graefe's or, still better, Beer's cataract knife is preferable to the lance-shaped knife, and the section should, to a certain degree, have the curve of the old flap, since the flap, on account of its easy opening, facilitates the manipulation of the instruments and offers the smallest obstacles to the expulsion of the foreign body. Corneal wounds of a moderate extent in an otherwise healthy eye have but little tendency to suppuration. We need not, therefore, be afraid of making the section too large. It might even be recommendable to raise the flap (which should always lie immediately below the foreign body) with a blunt-pointed probe or squint-hook, thereby exposing the foreign body and rendering its removal easier. The patient should be operated in the recumbent position under an anæsthetic, and his pupil should be kept narrow by eserine instillations before and after the operation. This prevents the foreign body from falling into the sinus of the anterior chamber, and obviates as much as possible the prolapse of the iris.

If we have reason to suppose that the foreign body lies loosely upon the uneven anterior surface of the iris, it will be appropriate, while making the corneal section, to hold the blade of Beer's knife, not parallel to the iris, but in such a manner that its upper face forms with it an angle of about 140°, and lies underneath the foreign body, in order to enable the foreign body to escape with the aqueous, and preventing it from falling to the bottom of the anterior chamber.

In the removal of foreign bodies the following instruments have been used: a, *forceps;* b, *spoons;* c, *curettes* and *hooks.* Toothed forceps should only be employed when the foreign body is not hard, for instance when it consists of wood, so that the teeth of the instrument can be pressed into it, whereas from hard bodies:—metal, stones, etc., they slide off, and the foreign body is pushed more deeply into the iris and lens. The foreign bodies may be better seized by delicate but strong anatomical (grooved) forceps, and if we have to deal with round bodies, for instance bird shot, it may be advantageous to use a pair of forceps the ends of which are hemispherically hollowed out, like the bullet forceps of surgeons. Yet it may be difficult to make them delicate enough to be introduced and manipulated in the anterior chamber. Daviel's spoon may be very appropriate in some cases, and has, for instance, rendered good service to Prof. Horner, as he tells us in his valuable paper on "Foreign Bodies in the Iris, four cases."*

In the majority of cases, however, a curette will be preferable to either the spoon or forceps, since its point admits of seizing the foreign body from behind, thus affording a firmer hold of it and avoiding the danger of forcing it more deeply into the eye. In some cases, it will be best to draw the foreign body with the grooved hook into the wound, and if it be there retained in consequence of its angular edges, to keep it pressed against the wound from behind until it is securely seized and extracted with pincers or pried out with a Daviel's spoon.

CASE IX.—*Iron splinter in the iris extracted with hollow hook.*

Five years ago, a Swiss workman in an iron factory came to me at 9 o'clock in the evening. A piece of steel had struck his eye that afternoon. He had a small wound in the lower half of the cornea. The anterior chamber was incompletely filled and a splinter of metal, about $1\frac{1}{2}'''$ in length, lay on the iris a little underneath the pupillary edge; the pupil was narrow, regular, and clear; sight good. I at once undertook to remove it, placing the patient in a half recumbent position on the operating chair in the ophthalmoscope room, illuminated, with a forehead mirror, his eye which was kept open by the ordinary wire speculum. Steadying the eye with the fixing forceps, I made a corneal section under the wound with a Beer's cataract knife. Then I introduced the grooved hook into the chamber, behind the foreign body, which was seized and extracted without difficulty. A small protruding part of iris was replaced with a probe. The pupil was round. I instilled atropine, bandaged the eye, kept the patient as a guest in my residence for two days, and had the pleasure of sending him home with a round pupil and perfect vision.

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* Zehn. Klin. Mon., 1863, page 395, etc.

In former years, I used for the extraction of foreign bodies the broad blunt hook which v. Graefe recommended as a traction instrument in certain cases of cataract extraction by his peripheric linear section. Later, I had this instrument changed in such a way that its concave surface was hollowed out and roughened to seize foreign bodies more securely than by the instrument with smooth and convex surfaces from which extraneous bodies are more apt to slide off. This little instrument has been manufactured and sold for several years by Messrs. Tiemann & Co., and some other American and European instrument makers, for instance, Windler in Berlin, Leiter in Vienna.

If the foreign body is situated more deeply in the tissue of the iris, and attempts at seizing it with the hollow hook or forceps have failed, it should without further deliberation be drawn out together with the piece of iris enveloping it, and the iris cut off. This, for instance, is illustrated in a case of Dr. T. R. Pooley, in which a chip of iron had lain in the iris one week and produced iritis with hypopyon. He extracted it with Liebreich's forceps, after having failed with the hook. Abscission of the prolapsed and lacerated iris. Recovery. (Transact. N. Y. State Med. Soc., 1875, p. 194.) This mode of removing foreign bodies in the iris has, of late, been highly recommended. It is the surest and simplest, but also, if the expression may be allowed, the cheapest modus operandi. Every oculist has the instruments necessary for this operation always at hand and is familiar with the procedure, but it causes a large coloboma, which is commonly directed downward —an inconvenience which should be a sufficient reason for every operator to give his earnest attention to a method of removing foreign bodies without iridectomy. Though foreign bodies are more frequently met with in the iris than in any other membrane within the eye, and a number of successful removals have been made known, yet I would beg leave to report two other cases in my own practice in corroboration of the preceding remarks.

CASE X.—*Piece of iron in the iris which could not be removed with forceps, but was easily extracted with the hook. Recovery.*

On the 23d of December, 1865, Theodore Wüstel, of Kohlenfeld near Rastett, entered the clinic at Heidelberg. Four weeks previously, a small piece of iron entered his eye, since which time the eye had been inflamed. In the upper part of the cornea, a superficial loss of substance was seen, resulting, the patient alleged, from the endeavors to remove the foreign body. In the inner upper part of the iris there was a black point, not distinctly recognizable as a foreign body on account of the dullness of the iris and turbidity of the aqueous humor. In the hospital, his iritis increased and hypopyon formed, for which a paracentesis of the anterior chamber was made December 27th. The inflammation abated, the hypopyon disappeared, and the presence of a foreign body could be ascertained. On Jan. 1st, 1866, I made an opening into the lower part of the cornea with a lance-shaped knife, endeavored to seize the foreign body with a pair of delicate iris forceps, but failed; then tried to extract it with Graefe's broad hook, and succeeded at the first attempt.

The foreign body proved to be a black needle-shaped piece of iron, 1½ lines in length, which was loosely covered with a white, viscid coating. After the operation, the iris showed a defect ⅔ of a line in diameter, which was probably produced by the forceps. The pupillary edge was intact; no bleeding; anterior chamber in part rapidly restored; recovery good. Nine days after the operation the patient was discharged with a round pupil dilated by atropine, clear lens and cornea, and good vision.

CASE XI.—*Removal of two small pebbles from the anterior chamber; the one with a blunt hook, the other by means of iridectomy. Recovery.*

Charles Glück, 30 years old, of Unteroewisheim near Bruchsal, came to the Heidelberg Ophthalmic Clinic on Nov. 14th, 1867, stating that a week ago a foreign body had struck his eye. *Status præsens:* Great circumcorneal injection, photophobia, intense pain; a linear scar in the vertical meridian of the cornea. Anterior chamber filled; iris hyperæmic, dull; a grayish-red piece of stone lies on the posterior surface of the cornea, a similar one on the iris near the lower ciliary border.

I made an incision in the lower edge of the cornea, introduced a blunt hook, and drew out without difficulty the piece of stone which lay upon the posterior surface of the cornea. The other piece of stone had protruded together with the iris. It was seized with the iris enveloping it, drawn clear of the wound, and the iris abscised. Recovery perfect; pupil dilated by atropine ; lens uninjured ; patient discharged with good sight six days after the operation.

IV. *Foreign Bodies in the Sinus of the Anterior Chamber.*

The bottom of the anterior chamber is the usual resting-place of round and heavy bodies—for instance, small shot—that may have entered the anterior chamber. Yet it is much more frequent that such bodies continue their course, penetrating into the iris and lens, or still more deeply, if the propelling force has been sufficient to overcome the resistance of the cornea. On the other hand, it is not at all infrequent that foreign bodies, lodged deeply in the cornea, are forced by unskilled hands into the anterior chamber and sink to the bottom, where it is difficult to see and still more difficult to dislodge them. I have observed several such cases. In one instance I succeeded, without making an iridectomy, in extracting by means of a hollow hook passed through a corneal section, a small piece of stone from the chamber sinus, where it was imbedded in the tissue of the iris. It has also happened to me once to mistake a small black particle, enclosed in exudation at the bottom of the anterior chamber, for a piece of iron which had penetrated the eye and could not be found. It was only when I had touched the supposed foreign body with the hook that I became aware of the mistake. Desmarres,* in such cases, recommends to make a very peripheric cut through the scleral border with a cataract knife, and to extract the foreign body with a curette. This procedure should be combined with iridectomy, even though we now possess in eserine a powerful myotic, for in such peripheric wounds, prolapse and incarceration of the iris can hardly be avoided. Only lately I saw a very sad instance (sympathetic iritis) illustrating the well-known danger attending incarcerated iris.

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* Traité, vol. II., p. 314.

V. *Foreign Bodies in the Posterior Chamber.*

I have no experience of my own in such cases, and, dreading controversy, I refrain from criticising that of others. In opposition to the opinion of Helmholtz, which is derived from examinations of the living physiological eye, and assumes that only a minimal quantity of liquid exists between the zonule of Zinn and the capsule on the one hand, and the iris on the other, almost all oculists consider as the orthodox eye the eye of Arlt, which is constructed from anatomical examinations of frozen specimens, and provided with a spacious posterior chamber. Nevertheless, from a practical point of view, I believe that, whenever there is a considerable space between the periphery of the lens and that of the iris, it is the result of pathological action, *id est*, morbid products. To assume that a foreign body may penetrate the anterior chamber, be arrested by the unbroken anterior capsule, and fall into the posterior chamber, is, in my opinion, not only unproven, but almost impossible, since everybody knows that, at the pupilliary edge at least, the iris is closely applied to the lens.

I have repeatedly seen that foreign bodies in the anterior chamber, by unsuccessful attempts at removal, have been more deeply forced into the peripheric tissue of the iris, even so deeply that they could no longer be seen. Violent inflammations ensued, during which a plug of pus sometimes protruded from behind the iris into the pupil. In all such cases I have assumed that the foreign body lay in the periphery of the iris and the head of the ciliary body, and I have never ventured to attempt its removal, since in the cases which came under my observation, the site of the foreign body could not be ascertained with sufficient certainty. Nevertheless, if a similar case should again come under my care, I would make a broad peripheral iridectomy, and if the foreign body should not come out with the iris or be visible after the iridectomy, I would carefully and gently probe the adjacent ciliary region.

If by this manœuvre I chanced to touch the foreign body, I would try to extract it with the hollow hook, but in case of failure I would at once enlarge the sclero-corneal section and poultice the eye, in order to produce suppuration of the globe. Such a procedure was first practised by Barton, of Manchester, and described by Crampton in the London Med. Gaz.* I find it quoted in the text-book of W. Lawrence,† and it is recommended by McKenzie and Arlt (Injuries) in lieu of extirpation of the globe in such cases where the foreign body in the interior of the eye cannot be found, and keeps up a painful inflammation which may affect the other by sympathy. Barton's method consists in making an ordinary corneal flap which is cut away with scissors. After that, poultices are applied to the eye. In a short time, the foreign body is expelled by the ensuing suppuration. The painfulness, which, after extensive opening of the globe, is commonly not very great, and can be rendered tolerable by anodynes, is more than counter-balanced by the resulting good stump. Yet in the choice between this procedure and enucleation, the age, sex, and social condition of the patient should be taken into account.

B.—FOREIGN BODIES IN THE VITREOUS CHAMBER.

The reactions produced by foreign bodies that have entered the posterior part of the globe and remained either in the vitreous chamber or its walls, the retina, ciliary body, choroid, and sclerotic, are illustrated by numerous examples both in the earlier and modern literature (Edw. v. Jaeger, Wiener Krankenhausbericht, 1857 and 1858. A. v. Graefe, his Archiv, Vol. III., 2. R. Berlin, and others). But the number of cases in which foreign bodies have been removed from the posterior part of the globe is very small. J. P. E. Ballias, in his paper, "Des Corps Etrangers du Corps Vitré,"‡ has compiled fifty cases, in twelve of which the extraction of the foreign body had been attempted, in three with success. He adds no new cases, and gives no notes of those used in his statistics.

The cases of successful or only partially successful removal of foreign bodies from the vitreous chamber and its walls are so rare that they may be considered almost as exceptions.

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* Vol. 21, p. 175.

† 2d Ed., p. 145, 1844.

‡ Thèse de Paris, 1865.

The reason of this is chiefly to be attributed to two conditions: *first*, the patients present themselves to the physician only when an exact determination of the site of the foreign body is no longer possible; *secondly*, the operative procedures have not yet been sufficiently perfected.

The influence of both these conditions diminishing from year to year, I feel confident that in future a relatively greater number of successful extractions of foreign bodies from the posterior part of the globe will be made known. Zander and Geissler have compiled the respective cases up to the year 1864. They are six in number: three cases (v. Graefe, 1; Ed. Jaeger, 2) in which the foreign body had pierced the coats of the eye, but remained impacted with one end in the sclerotic, while the other projected into the vitreous. In the first two cases, the foreign body was detected soon after the injury, and drawn out with forceps; in the third, the foreign body was not found, but later an inflammatory intumescence (partial choroiditis) occurred at the injured place, showing an almost black coloration of the sclerotic to the extent of ½‴. When, thirty days after the injury, an incision was made in this place, the foreign body was felt with a delicate probe, and extracted. In these three cases, recovery with preservation of sight ensued.

In the fourth case,* the foreign body had penetrated into the vitreous through the cornea and iris. Critchett, after having extracted the opaque lens, saw an oblong piece of metal behind the hyaloid fossa. It could not be seized with forceps, but was drawn out with a curette, not without escape of vitreous. Final result not stated.

In the fifth case, Desmarres seized a fibrous cord, which proceeded from a foreign body that was movable in the anterior part of the vitreous, with a pair of forceps which he had introduced through a scleral opening; after wrapping the fibrous cord around the forceps, he extracted a small piece of copper connected with the cord, measuring 2‴ in length and 1‴ in breadth. The eye became free from pain, but atrophic.†

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* Critchett: The Lancet, April, 1854, p. 858.

† Annales d'Ocul., XXIII., p. 16; Zander and Geissler, p. 217.

The sixth case, of Dixon,* has been often quoted. A foreign body had pierced the upper lid and sclerotic. It was not until four weeks later that a dark oval foreign body was seen in the anterior inner part of the vitreous. It moved with the eye, and could be drawn toward the wall of the globe by a large magnet. Dixon thrust a lance-shaped knife through the sclerotic, perpendicularly to the direction of the fibres of this membrane, seized and extracted with Assalini's forceps, after two unsuccessful attempts, a chip of steel of 1 mm. in length. Good recovery. A small cord in the vitreous was still visible after one month and a half.

I have collected the cases recorded in modern literature from Cannstatt's (*i.e.*, Virchow-Hirsch's) and Nagel's Annual Reports, and looked them up in the original publications as far as they were accessible to me. Since their number is limited, I do not deem it entirely superfluous to cite them in short extracts.

R. Berlin reports† a case which is very remarkable from an operative point of view. A lad of fifteen years had been injured two weeks before he presented himself. The interior of the eye was not visible on account of inflammatory turbidity. S.=$\frac{1}{\infty}$. T. increased. Two lines behind the inner edge of the cornea, a circumscribed swelling of conjunctiva. When Berlin enucleated the eye, and had divided the internal, inferior, and external recti muscles, he met with a foreign body lodged in the posterior outer part of the sclerotic, and extracted it. It was a small splinter of iron with sharp edges, and had $2\frac{1}{2}'''$ in length, $1'''$ in breadth, and $1'''$ in thickness. Dr. Berlin, after having satisfied himself, by probing with a squint hook, that no foreign body was left in the scleral wound and the adjacent part of the vitreous, united with sutures the tendons of the external and inferior recti again to the globe, and closed the lids by a compressive bandage. He left the tendon of the internal rectus untouched, since he was afraid (without sufficient reason) of diminishing the chances of recovery by applying too many sutures. The result was a complete reattachment of the globe, but slight atrophy and divergent squint, S.=0. The foreign body had evidently entered the anterior part of the sclerotic, passed through the vitreous, pierced the posterior wall of the globe, but had remained partially impacted in it.

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* Ophthalm. Hosp. Rep., I., p. 280.

† Zehend. Klin. Mon., IV., 1866, p. 81, ff.

This case suggests the possibility of coming across the foreign body even during the enucleation. Therefore, the first step of our operation should always be directed towards the supposed site of the foreign body.

As a curiosity, I beg to mention a case of A. v. Graefe's, in which, after the enucleation, a foreign body was found in the optic nerve 2''' behind the sclerotic. The foreign body had penetrated the cornea, and passed through the cavity of the globe and the optic disc into the optic nerve.

Foreign bodies that enter the globe at its anterior part have sometimes been found encapsulated and harmless in the background of the eye (E. Jaeger, A. v. Graefe, Hirschberg, and others).

In a case of G. T. Stevens,* of Albany, a foreign body was extracted from the retina. A fragment of iron, broken off from a hatchet, entered the eye through the periphery of the cornea and iris. Two weeks later, Stevens recognized it by its metallic lustre. It lay in the retina, behind the equator of the globe. Having by means of the ophthalmoscope determined the site of the foreign body as accurately as possible, he thrust a fine needle into the eye at the supposed place of the foreign body, and the opthalmoscope showed the needle projecting into the vitreous just at the anterior border of the foreign body. After making a meridional opening into the sclerotic, he saw the foreign body, surrounded by retina, presenting in the wound. With a pair of forceps, he drew forth the foreign body together with a piece of the retina and removed it. Two weeks later, the eye showed a defect in the visual field corresponding to the place of the operation. Two day after this, intraocular hemorrhage occurred. Two months after the operation, the media were still so turbid that the optic disc could not be seen.

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* Trans. Amer. Ophth. Soc., 1875, page 308.

A case of Schöler, published in the second annual report of his Ophthalmic Institution (pro 1874), is known to me only from the extract which Manz published in Virchow-Hirsch's Ann. Rep. on the Progress of Medicine. It reads as follows: "Schöler advises, in cases in which foreign bodies penetrated into the vitreous through the lens, to make linear extraction and seek for the foreign body under the condition that perception of light and the visual field are preserved, and that no dangerous symptoms of irritation are present. In one such case he succeeded in extracting a guncap, and the eye recovered good vision."

A case reported by Sp. Watson,* is very remarkable. A bird-shot had pierced the sclerotic $4'''$ downward and inward from the cornea, and lay in the eye for two weeks. Opacities of the vitreous. Sight lost. Violent pain. When an "iridectomy was made, the bird-shot fell out. The exit of the shot far in front of the place of perforation in the sclerotic is most remarkable. Watson thinks that the bird-shot may have moved forward and downward by its own weight."† According to the important investigations of R. Berlin, we may suppose that it struck the posterior wall of the globe and was repelled.

Concerning a case of Hansen, I find, in Canstatt's Jahresbericht, only the following short note: "Hansen reports a case in which he removed, by means of modified linear extraction, a guncap from the vitreous chamber."

Dr. R. Berlin, in his first paper,‡ "On the Course of Foreign Bodies that have Entered the Vitreous," states that he has twice performed the extraction of foreign bodies from the vitreous. The paper, however, makes no further mention of these cases, unless the statement on p. 307, l. c., refers to one of them. "The attempt to extract the foreign body, after enlarging the wound, failed. The foreign body was only pushed downward and out of sight." It remained in the eye, and caused detachment of the retina.

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* Lancet, 1872, II., page 598.

† Nagel, Jahresbericht, 1872, page 473.

‡ Graefe's Archiv, XIII., 2, p. 275, etc., 1867.

The masterly second paper* of R. Berlin contains more data pertaining to our special subject. In one case (loc. cit., p. 277), a small scar was situated just above *lower* the corneal margin. Lens opaque. Five lines behind the *upper* corneal margin, a red swelling, sensitive to the touch; corresponding to it a circumscribed defect in the lower part of the visual field. The injury had occurred a week previously, from the explosion of a gun loaded with a blank cartridge. Eleven days after the accident, Berlin opened the swelling on the superior wall of the globe, and removed a fragment of a guncap, one square millimeter in size, imbedded in a small collection of pus lying between the sclerotic and the tendon of the superior rectus. Recovery. The guncap had passed through the cornea, lens, vitreous, and sclerotic, and had been arrested by the tendon of the muscle. Patient was discharged with quantitative perception of light and cataract.

Berlin's investigations led him to the conclusion that a small number of the foreign bodies that enter the vitreous chamber lodge in the retina and choroid at the posterior part of the globe; wheras the greater number are repelled in such a way that the lighter ones—for instance, thin scales of metal—float in the vitreous; but the heavier ones, especially pieces of iron, sink to the bottom, and are commonly situated between the equator and ciliary body.

They may be sometimes diagnosticated by the sensibility of the sclerotic to the touch, but more frequently by corresponding defects in the visual fluid. They can be directly reached through an opening into the sclerotic, three lines behind the corneal margin.

In two such cases, Berlin has attempted their extraction. In the one (l. c., p. 321), he made a circular section, three lines in length, four lines and a half behind the cornea, and while cutting distinctly felt the foreign body with the knife. He passed a pair of forceps and a probe through the section into the posterior part of the vitreous chamber, without, however, finding the foreign body, which, as the examination of the subsequently enucleated globe showed, was situated just in front of the circular section.

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* Observations on Foreign Bodies in the Vitreous Chamber. Graefe's Arch., XIV., 2, p. 275, etc., 1868.

In the second case (p. 325), he made, three lines behind the cornea, a circular cut, four lines in length. A piece of iron, three lines long, half a line broad, presented at once, and was easily extracted. The eye grew phthisical.

In these ARCHIVES,* Berlin reports two cases in which he removed extraneous bodies from the vitreous chamber. In the first, he availed himself of the large corneal wound which the foreign body had made. In the second, he extracted the lens after an iridectomy, then opened the hyaloid fossa, probed for the foreign body, and extracted it with forceps. Both eyes, of course, were ruined.

J. F. Jeaffreson, in an instructive paper,† reports a case of successful extraction of a small piece of iron from the vitreous. It flew from a lathe, and entered the eye through an opening one line and a half behind the cornea, "where, after the dilatation of the pupil, it could be seen in the vitreous, a little above and to the nasal side of the visual axis. A fine pair of canula forceps was passed along the track of the wound until it came in contact with the foreign body. The blades were then opened, and it was seized and removed without difficulty. For some weeks after, the vitreous was very hazy, and then began to clear up. At the discharge of the patient, two months after, V.=$\frac{1}{10}$."

In conclusion I have to mention a case distinguished by the use of a magnet for the extraction of the foreign body. Wm. A. McKeown relates‡ that he detected with the ophthalmoscope a chip of steel, shortly after it had entered, through the periphery of the cornea and iris, deeply into the vitreous body. The day after, inflammation and opacity of the vitreous. McKeown made an opening into the sclerotic, two lines and a half in length, and two lines and a half behind the outer corneal margin. After having failed to extract the foreign body with iris forceps, he introduced the two rounded united ends of an eight-inch horse-shoe magnet into the wound toward the posterior pole of the globe. The foreign body was attracted by the magnet, but on withdraw-it, it was twice arrested by the sclerotic. At the third attempt, however, it was successfully extracted. Three days after, the patient could leave the hospital. Four weeks after, he had S.=½ and a small limitation of the visual field toward the nose, probably produced by a detachment of the retina. (This case is quoted from R. Berlin's review in Nagel's Jahresbericht, 1874, p. 579.)

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* Vol. I., p. 30, etc.

† On Foreign Bodies in the Eye. Med. Times and Gazette, March 28th, 1874, p. 342, Case 6.

‡ Brit. Med. Journ., June 20th, 1874.

To these preceding cases I can add three from my own practice, in which I succeeded in extracting foreign bodies from the vitreous. I have extensive notes of two of them, one being still under my observation. I have not been able to find the history of the third in my books, still I remember its essential features.

CASE XII.—*Foreign body in vitreous, removed with blunt hook. Recovery, leaving cicatricial cord.*

The patient, a boy, son of the janitor of the old University Hospital at Heidelberg, came to me a few hours after a foreign body, a guncap, if my memory serves me, had entered his eye. A small wound in the outer part of the sclerotic was kept open by a bead of protruding vitreous. With the ophthalmoscope I saw the foreign body floating in the vitreous, and proceeded at once to remove it. Armed with a forehead mirror, I illuminated in the ophthalmoscope room the interior of the eye, while an assistant steadied the head of the patient who was sitting. I passed a blunt Graefe's hook through the wound into the vitreous behind the foreign body, which I drew to the scleral wound ; there it was arrested, but a part of it presented in the wound so that I could seize the foreign body with a pair of anatomical forceps, and, while the hook was fixing it from behind, extracted it, not without some force. The loss of vitreous was insignificant. I bandaged the eye in the usual manner, and the scleral wound soon closed. The vitreous body was at first diffusely opaque, but cleared up in several weeks, and the patient could count fingers across the room. Later, I observed more and more distinctly a cicatricial cord arising from the wound and stretching in the direction of the course which the foreign body and hook had taken. I saw the boy every now and then; his eye was free from pain; vision moderately good, and no irritation in the other eye. I do not know what finally became of the eye.

CASE XIII.—*A piece of iron in vitreous, removed with anatomical forceps. Recovery, leaving opacities of vitreous.*

John Schaller, of Ziegelhausen, near Heidelberg, came to the clinic June 19th, 1866, several hours after a chip of iron had pierced the inner part of the sclerotic. He could read Snellen 2.50 on a cloudy day with this eye as well as with the other. After the pupil was dilated, I observed a fragment of bright metal in the anterior outer part of the vitreous, not very far behind the lens, which, impelled by the movements of the eye, made slight excursions; I at once proceeded to remove it. With a lance-shaped knife I made a meridional opening three lines in length in the outer part of the sclerotic, and made two attempts to extract the foreign body—the first by daylight, the second by lamp-light with the ophthalmoscope—but failed both times, the illumination proving insufficient. Then I had the light of a large gas-flame from an Argand burner thrown through the pupil into the vitreous space by means of a lens, and concentrated it upon the foreign body which I could now see well, and tried to draw into the wound with a Graefe's blunt hook, yet could not succeed; then I entered with a pair of anatomical forceps, seized the small piece of iron firmly, and drew it out without any difficulty.

Immediately after the operation the vitreous was turbid, yet I could see the details of the background of the eye, and convinced myself that there was neither hemorrhage nor anything else abnormal. On the nasal side, where the foreign body had entered the fundus, was a bluish hue (detachment of retina [?]); also on the opposite side, where the wound of the operation was situated, I noticed a bluish, but very small fold. The visual power was only superficially examined, the patient could count fingers, and the visual field was not materially contracted.

Rather intense inflammation followed, pain during the night, conjunctiva red and swollen, cornea and pupil clear; posterior portion of vitreous on oblique illumination presented a dull, grayish, striated appearance. On the third and fourth days after the operation, eyeball slightly protruding; pupil remained wide; iris was not discolored; patient saw movements of the hand; field of vision complete. From the fifth day the eye improved. Four weeks after the operation, patient discharged; counted fingers, had no contraction of visual field. Diffuse opacity was in the whole vitreous, flaky opacities were in its lower part, and membranous opacities arose from the wound.

CASE XIV.—*Guncap in vitreous, removed with grooved hook. Perfect recovery.*

A boy, R. T., of New York, æt. 7, injured his left eye by discharging a toy pistol on June 25th, 1873. I saw him two days later, and found a piece of iris protruding through a small wound in the upper part of the cornea. I observed, through the dilated pupil, about in the centre of the vitreous, a bright metallic body with sharp corners and irregularly curved edges, having an apparent length of $2\frac{1}{2}'''$ and a breadth of $1\frac{1}{2}'''$. The vitreous was clear, the background only very slightly veiled, the optic disc and the whole retina hyperæmic; the veins in particular were thick and tortuous; the retina in the vicinity of the disc was somewhat opaque and apparently swollen.

On the same day I extracted the foreign body in the following manner. At first I threw light from a large gas flame into the patient's eye by means of a forehead mirror, which indeed rendered the foreign body distinctly visible. But when I placed the patient in a well-lighted room, opposite the window, I could, without the mirror, see the bright foreign body as well, and preferred this position, since it afforded a free movement of my head during the operation. The patient was deeply anæsthetized, placed horizontally on his right side, the pupil of the injured eye being turned directly toward the window. The lids were kept apart by a wire speculum, and the globe was slightly turned towards the nose with forceps. Then I made with a lance-shaped knife an opening two lines and a half in length through the coats of the eye, a little in front of the equator, and just over the edge of the external rectus muscle. I introduced a delicate but strong pair of anatomical forceps, before which, however, the foreign body escaped when touched. I therefore at once withdrew the forceps from the eye and introduced the above-described grooved hook, passed it behind the foreign body, seized it firmly, and drew it into the scleral wound, where it was arrested, and slipped from the hook. Since the opening was too small, I enlarged the wound with squint scissors, seized the foreign body anew with the hook, and extracted it without difficulty. Not more than a drop of vitreous escaped. On account of some bleeding from the wound the eye was kept closed for some time. When the patient came to, the wound gaped. He was therefore anæsthetized again, and the scleral wound was closed by a conjunctival suture, a small quantity of fluid vitreous escaping. The protruded iris in the original corneal wound was seized with forceps, drawn out, and cleanly cut off. When the patient had regained his consciousness, he could count fingers well; I therefore instilled a drop of atropine in the eye, then bandaged both eyes, and had him put to bed.

June 28th.—Night tolerably quiet; pain in eye every now and then; thirst; edge of lid somewhat swollen, pale; the whole conjunctiva of the sclerotic uniformly but only moderately swollen, except in the region of the wound, where it is more raised; anterior chamber normal; pupil fully dilated; pulse 100; counts fingers at 6′.

June 29th.—Rested well; charpie moist, not purulent; injections of conjunctiva the same; region of wound, however, less swollen; patient recognizes time at watch; circumscribed defect of visual field on nasal side; pulse 96.

June 30th.—Night good. Some mucous secretion on lint; injection and swelling of conjunctiva less; pupil clear; scar of iridectomy clean; no irritation in scleral wound; background of eye slightly veiled; retina hyperæmic; counts fingers across the room. Defect in visual field no longer recognizable on ordinary examination with hand.

The further course of the case was an undisturbed convalescence. The wound closed on the 7th day after the operation, and the suture was then removed. On the 14th day, S.$=\frac{20}{70}$; F. complete. With the ophthalmoscope, a white oval scar, about 2 P. D. in length, was seen at the place of the wound. Patient read Sn. 1½ readily. In the upper part of the cornea there was an irregular small scar, to which the iris adhered. Six months after the operation, pupil was oblong, drawn towards the scar. The minor circle of the iris was free in the anterior chamber, the peripheric upper and outer part of the iris united to the scar; lens clear; fundus normal; vitreous without a trace of opacity. The white patch in the region of the wound had quite the appearance of a coloboma of the choroid, was about 2½ P. D. long and 1½ P. D. broad. It did not manifest itself by a scotoma noticed by the patient. S. $\frac{20}{30}$; in the other eye, S. $\frac{20}{20}$. Tn., binocular vision perfect.

The eye remained unchanged in this condition for five years, then a serous cyst developed in it, which I removed in October, 1858. In presenting the specimen to the New York Pathological Society, I gave also a brief sketch of the previous history of the patient.* I beg also to state that I shortly mentioned the above case at the meeting of the American Ophthalmological Society, in 1873, on the occasion of the demonstration of the grooved hook and two other instruments.†

A COMPREHENSIVE REVIEW of the preceding observations on the removal of foreign bodies from the vitreous yields the following results. I have not been able to collect more than twenty cases in which a foreign body had been removed from the vitreous chamber.

In the first three cases (v. Graefe, one; Ed. Jaeger, two), the foreign bodies pierced the sclerotic, but remained impacted in it. They were easily extracted. Recovery with preservation of good sight.

Excluding, in the following, these three comparatively simple cases, and considering the other seventeen according to special points of view, we arrive at the following statements:

I. *Entrance and course of the foreign body.*

In *seven* cases, the foreign body entered the vitreous directly through the sclerotic.

In *ten* cases, it entered through the cornea, *id est*, in seven through the lens, in three (McKeown, Stevens, Knapp) through the periphery of the iris without wounding the lens.

II. *Position of the foreign body at the time of the operation.*

In *two* cases (both of Dr. Berlin), it pierced also the posterior capsule of the globe, remaining impacted, in one case, in the sclerotic; in the other, between the sclerotic and the tendon of the superior rectus muscle.

In *one* case (Stevens), it lodged in the retina.

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* See Med. Rec., Nov. 2d, 1878, vol. XIV., p. 353.

† Transactions Am. Ophth. Soc., 1873, p. 108.

In the fourteen remaining cases, it was situated in the vitreous body.

III. *Opening of the globe for the extractions.*

In *two* cases (Jeaffreson and Knapp), the original opening of the wound was made use of, but had to be enlarged in one case (Knapp).

In *nine* cases, a new opening was made in the sclerotic, *id est*, four times in a circular (parallel to the equator), and three times (Stevens, one; Knapp, two) in a meridional direction; in two cases (Desmarres and McKeown), the direction is not stated.

In *six* cases, the extraction of the foreign body was effected through the cornea, *id est*, in one case (Watson), with simultaneous iridectomy; in one (Berlin), making use of the original large wound in the cornea; and in four (Critchett, Berlin, Hansen, Schöler), preceded by a modified linear extraction of the lens.

IV. *Instruments used in the removal of the foreign bodies.*

In *eight* cases, the forceps, among which in one the canula forceps, in another Assalini's forceps.

In *one* (Critchett), a curette.

In *one* (Knapp), a grooved hook.

In *one* (McKeown), a magnet.

In *one* (Sp. Watson), the foreign body dropped out by itself.

In *four*, instrument not stated.

V. *Course and termination of the cases.*

In *two* cases (Berlin, Hansen), the termination is not stated.

In *six* cases (Desmarres, one; Berlin, four; Sp. Watson, one), loss of sight which in a part of them was already present before the operation.

In *four* cases (Critchett, Stevens, Knapp two), moderately good vision, when patient was last seen, was stated, with a doubtful prognosis as to the future.

In *five* cases (Dixon, Jeaffreson, McKeown, Schöler, Knapp), vision was good. To these must be added the first three cases in which the foreign body projected into the vitreous space with one end only. In Dixon's case, the acuity of vision is not stated, but it is said that a small cord remained visible in the vitreous. In Jeaffreson's case, at the discharge of the patient S. $\frac{1}{10}$ is noted with progressing clearing of the vitreous. In McKeown's case, S. $\frac{1}{2}$ with a small defect in the visual field, twenty-eight days after the operation. In Schöler's case, preservation of good vision is noted. In the last case operated on by myself, S. was $\frac{2}{3}$ for five years, then a cyst of the iris developed which was successfully removed, leaving his vision still $\frac{2}{3}$, but the possibility of a relapse cannot yet be excluded.

I will not omit to deduce from the preceding pages some rules as to

PROGNOSIS AND TREATMENT.

The cases in which the foreign body enters the vitreous through the sclerotic are, in general, more favorable than those in which it enters through the cornea. Among the latter, those in which the foreign body passes through the periphery of the iris without injuring the lens are more favorable than those complicated by traumatic cataract. The most favorable, of course, are those in which the foreign body pierces the sclerotic, but remains in it with one end.

As regards the operative procedures, I will first mention the two methods devised by A. von Graefe, and especially practised for the removal of cysticerci, viz.: 1st, the extraction of the foreign body through the cornea, preceded by peripheric linear extraction of the lens, and, 2d, the extraction of the foreign body through an opening in the sclerotic by a circular section. Both methods involve great dangers. The first I consider admissible only when traumatic cataract is present. If, after the removal of the cataract, the foreign body cannot at once be seen with oblique illumination or the ophthalmoscope, three methods of operating are at our disposal: First, we may wait until the wound is healed and the eye has cleared up, to determine the site of the foreign body with the ophthalmoscope, and either trust to its becoming encapsulated, or remove it through a scleral opening. Secondly, we may with a probe, or, still better, with a hollow hook, search for the foreign body. This procedure, I think, is very hazardous, though it is supported by a successful operation (Schöler), the details of which I am unfortunately unable to look up. Thirdly, the immediate enucleation of the eyeball. This operation I would perform without delay in all cases in which symptoms of violent irritation indicate beginning panophthalmitis. The immediate enucleation, that is, without first extracting the lens, I consider the most advisable in all cases in which we are sure that the foreign body has passed through the lens. The danger of sympathetic affection is not counterbalanced by the slight chance of extracting the foreign body with preservation of a useful eye.

I fail to see what advantage a circular section through the sclerotic may possess over a longitudinal one. A circular section divides transversely the nerve-fibres of the retina, the larger vessels of the choroid, and the principal fibre-tracts of the sclerotic, thus inflicting a far more important and prejudicial wound. As far as my experience concerning wounds of the sclerotic goes, longitudinal sections heal just as easily as transverse sections. The available space is sufficient for a longitudinal section, since a section beginning two lines behind the cornea and ending at the equator or a short distance beyond it, will suffice for the extraction of all foreign bodies from the vitreous. After the operation, the wound should be closed by conjunctival sutures. As far as I am aware, in the extraction of cysticerci the longitudinal section is of late years mostly preferred to the circular section.

In regard to the *choice of the instruments*, the hollow transversely grooved hook might in most cases be given the preference. Toothed forceps are to be decidedly proscribed in the extraction of hard bodies (almost the only ones here met with), and also the transversely grooved forceps might serve more frequently to seize the foreign body after it has been drawn into the wound by the hook than to be introduced into the eye.

If we have to deal with small particles of iron, they may be drawn towards the wound in the sclerotic by a magnet applied to the outer side of the globe, whereas the introduction of a magnet into the vitreous space (McKeown) appears to me more injurious than the introduction of the hollow hook. The canula forceps and Assalini's forceps have been successfully used, each in one case; but as regards the availability of the former, I have heard many complaints which are confirmed by my own experience, and Assalini's forceps, opening on pressure, might, on account of the unwonted mechanism, in uncertainty of seizure still surpass the ordinary forceps. To thrust a fine needle into the sclerotic, as Stevens has done, in order to determine the site of the foreign body and be a landmark during the operation, seems to be as harmless a procedure as it may be useful; the needle may at the same time serve as a fixing instrument, and for this purpose it might appropriately be made with a knee-like bend, so that during the operation the handle of the instrument and the hand of the assistant are out of the way.

In regard to the *value* of the extraction of foreign bodies from the vitreous chamber, the foregoing statistics—five successful and four moderately successful cases of seventeen—seem to countenance the performance of this operation. If the foreign body lies in the vitreous space, and the corneo-ciliary part of the globe has not been materially injured, the operation may be justifiable even if we cannot hope to preserve the sight of the eye. In making the section, we should bear in mind the results obtained by Dr. Berlin's investigations, in particular that one which demonstrates that heavier foreign bodies almost invariably lodge in the anterior lower portion of the vitreous, and may be extracted through a scleral opening made three lines behind the cornea.

Since the necessity of removing a foreign body from the interior of the eye may devolve upon any oculist, or even upon any practitioner, at any hour, I beg in conclusion to indicate the *armamentarium* required for that purpose.

1st. *A magnifying glass*, *ophthalmoscope*, and *forehead mirror*.

2d. *A lid speculum* and *fixing forceps*.

3d. *A broad needle* with one slightly hollow surface, to push back foreign bodies that are lodged in the ocular capsule, and either perforate or threaten to perforate it; furthermore to prevent such bodies from falling into the interior of the eye, and from injuring important parts.

4th. *A Beer's cataract knife.*

5th. *An angularly bent, lance-shaped knife.*

6th. A pair of *curved iris forceps* to perform iridectomy.

7th. A pair of *curved* (squint) *scissors*, to cut off the iris and enlarge the wound.

8th. *A knee-bent delicate needle*, to be thrust into the vitreous for the purpose of "orientation."

9th. Delicate *anatomical forceps.*

10th. A transversely *grooved hollow hook.*

11th. *Needle*, *thread*, and *needle holder*, for closing the scleral wound.

It will be apparent that only Nos. 3, 8, and 10 have to be added to the ordinary instrument case of the oculist. The broad needle might be replaced by the cataract knife, and the knee-bent delicate needle might not be absolutely necessary either, but I would not like to be deprived of the hollow hook.

ON THE NUTRITION OF THE EYE AND THE AVENUES OF EXIT OF THE INTRAOCULAR HUMORS.—CRITICAL AND EXPERIMENTAL INVESTIGATIONS.

By Dr. MAX KNIES,

Assistant Surgeon to the Eye-Clinic in the University of Zurich.

Translated by Dr. E. S. Peck, of New York.

The subject of the nutrition of the eye and its individual tissues is a difficult, and at the same time but little developed chapter of ophthalmology. If the physiological conditions of nutrition in individual simple tissues are as yet poorly understood, it is doubly difficult to investigate these phenomena in an organ so complex as the eye.

Three ways are at our command for the determination of these pertinent questions, viz.: by experiment, by clinical observation, and by anatomical and pathologico-anatomical investigation. All three methods must be supplementary, and lead essentially to the same ends, would we insure reliance upon our results.

The experimental investigation of the questions involved has especial difficulties to combat. These lie, first, in the observation of tissues, not only living, but even in normal connection with the organism; and, secondly, in the impossibility of directly perceiving the materials of nutrition, and of tracing their channels. The experiment consists in introducing into the eye materials of the most neutral character, which may be either directly observed, or, by means of reaction, become fixed, and are hence easily perceived. It is obvious that materials best adapted to this purpose are actual coloring substances, or such as take on a faint but distinctly appreciable staining under conditions easily induced; and the less the quantity used, the better the result. But it is not sufficient that the materials be neutral: the art and manner of their application must be such that the eye itself will be the least possible affected by the invasion unavoidable in the experiment.

It is proper to note the agents used in the proposed experiments; they are salts of lithium, nitrate of silver, soluble Prussian blue, indigo-sulphate of soda (the so-called indigo-carmine), atropine, iodide of potassium, ferro- and ferrid-cyanide of potassium, soluble starch, and some other agents which can be properly ignored.

Lithium salts can only be recognized by means of the reaction of the flame in complete destruction of the tissues in which they are sought.

Nitrate of silver in like manner can be used only in a few cases, on account of its intense power; its sphere of usefulness lies chiefly in the exposition of pathological conditions.

Carmine is diffused too easily and too rapidly: so also indigo-carmine, the action of which, on account of the great expansion of the non-vascular parts, cannot, as in other tissues, be sufficiently well retained by immediate injection of the vessels with absolute alcohol.

Soluble Prussian blue is decolorized by means of the highly alkaline tissue juices, and can, therefore, easily lead to wrong conclusions.

Atropine and iodide of potassium have served with apparent success for certain experiments; but are not suitable, from very obvious grounds, for a more extended application.

Soluble starch, which is very easy of detection by reaction with iodine, is split in living tissues by the general action of ferments, which are either already present or very quickly appear, and the products resulting from the division are withdrawn from observation in most cases.

There still remain ferro- and ferrid-cyanide of potassium (yellow and red prussiate of potash), possessing very similar properties. The two cannot be directly demonstrated, but are very easy to see in the smallest traces by means of suitable reagents, and in small quantities are wholly neutral. The yellow prussiate of potash offers, however, many advantages: it checks the reducing influence of the tissues; while choride of iron, the reagent necessary to its proof, is soluble in alcohol, so that the coloring and the hardening of preparations can be achieved at one and the same time. I have, therefore, used it exclusively in my experiments.

There are two ways by which the agents appropriate for experiment can be introduced into the eye; through the channel of the general circulation, and by local application. The first method offers the greater protection to the eye; by it one may perceive in general where the introduced agents appear, and in what time and succession they are to be met with in individual tissues; but for the circumstances which are of interest here, and for all questions of a more special character, it is by no means sufficient. For these the second method must be adopted. It apparently produces a greater lesion; but in observing the necessary precautions, especially antiseptic measures, which in experimental work are as essential to the achievement of pure results as they are in a surgical clinic, the absolute harmlessnesss of the unavoidable lesion can be easily proved by parallel experiments.

My investigations extend over a space of four years, with more or less interruption, and, in part, have been already published.* A complete conception of the conditions of the nutrition of the eye was, however, only lately obtained, chiefly by following out into Tenon's capsule and the orbit the course of the substances injected into the globe. Some of these experiments will be described in their proper places.

Clinical experience constitutes, as it were, the verification of the results experimentally obtained. Unfortunately it is not always appreciated as it deserves, and it has become quite the habit of late to estimate experiments and their results over and above clinical experience. A single undeniable clinical fact outweighs many doubtful experiments; and negative experimental results, if opposed to positive clinical observations, must be regarded with especial precaution. We will have ample opportunity to make further allusion to this topic.

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* Virchow's Archiv, Vol. LXII., p. 271 ff., and LXV., p. 401 ff.

Experiments are frequently supplemented by anatomical and pathological facts. The development and extension of sarcomas of the choroid led me to the discovery of various, hitherto unobserved, details, relating to questions now under consideration. They, on the one hand, agreed most fortunately with the results of my experiments, and on the other, for this very reason, threw light on certain conditions not amenable to experiments. But we will recur to this in its proper place.

I wish here to say a few words on the manner in which experiments directed to the solution of the problem of the nutrition of the eye should be conducted. *Above all things, experiments on dead animals or on so-called fresh eyes are absolutely worthless in solving the questions with which we are engaged.* The circulation of the blood in the living animal is the most essential factor of nutrition; and the tissue-currents in the vascular and non-vascular parts of the eye, dependent upon the circulation of blood, are exactly what we wish to learn by the experiment. I emphasize this self-evident statement, because appearances in dead eyes, as well as in isolated tissues, are regarded by some as of sufficient proof to combat the opposite results of experiments on living animals. These appearances have, however, a limited value: they acquaint us with the conditions which would occur if no blood-current were present: and this is not without importance. A substance is introduced into a restricted region of the living eye *which does not exist there.* According to simple physical laws, this will be diffused equably on all sides, in dead as well as in living tissue. This equable diffusion is only modified, not arrested, by the tissue-currents, and the difference between its relation in living and dead tissue is precisely what we obtain as a result of experiment, and from which we may draw our conclusions.

A second requisite for the success of these experiments is the speediest possible setting of the injected agent after the stoppage of the circulation of blood in the part experimented upon.

As soon as the blood-pressure ceases, we have to do with purely physical conditions; and since a measurable time elapses between the excision of the eye and the influence of the reagents, the changes possible within this time must be taken into account.

Hence it follows that it is seldom or never possible to demonstrate in detail the whole current of fluid from the vitreous body to the orbit of the eye. In the majority of my experiments on *intraocular fluid-currents*, I have employed rabbits, whose eyes are very appropriate for the purpose, especially if we insure a prompt action of alcohol, acetic acid, and chloride of iron by means of suitable incisions and punctures. For experiments upon the further course of ocular fluids without the eye, rabbits are not suitable, as they possess almost no orbit whatever. Larger animals must be selected for this purpose. Experiments on the horse, cow, and goat, however, which I had the opportunity of conducting, through the kindness of the professors in the Veterinary School of Zurich,* suffer from another inconvenience, viz.: the exceedingly large size of the orbit; and hence lead to no result. On the other hand, I succeeded in obtaining good results from experiments on dogs and cats in the Pathologico-anatomical Institute in Zurich, to whose director, Professor Eberth, I owe my sincere thanks. The inner part of the eye can be used only with especial precaution, yet the results are positive enough to establish a conformity with my earlier experiments, the results of which I can confirm in their whole extent with only slight modifications, of which more later.

If we take a cursory view of the peculiarities which distinguish the eye as a whole from all other organs, we are first of all impressed with the fundamental difference between vascular or nutrient tissues, and non-vascular or nourished tissues. To the former group belong the whole uveal tract, retina, and sclera: to the latter, those tissues which are designated under the common name of refractive media; as, the vitreous body, lens, and cornea. It is readily understood that the latter must be nourished by the former. But a simple view will teach us *that the elements of nutrition of the whole eye are essentially concentrated in the uveal tract.* The independent circulatory system of the retina, for example, appears too slight to supply the substratum of function of sight, which we locate essentially in the outermost retinal layers; and, on the other hand, the uveal tract itself shows such an abundance of blood, and such a development of capillaries as to stand in glaring disproportion to its function. The total or partial absence of vessels in the retina of many and not merely small animals demonstrates that this membrane can sufficiently functionize without a special system of vessels; and one could be strongly tempted, from the analogy of the so-called comb of the eye of birds, to ascribe to the retinal vessels an importance for the vitreous body alone, if clinical facts did not incontrovertibly prove the necessity of the existence of retinal vessels, for the human retina at least.

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* I desire most heartily to thank Drs. Zschokke and Luchsinger for their readiness and friendly help.

The so-called border-loops of the cornea are apparently only in the smallest degree sufficient for its nutrition, and with the consideration of these two insignificant exceptions we may confidently assume *that the essential elements of nutrition of the whole eye are contained in the uveal tract.*

This relation is not the same under all circumstances. In the fœtus many parts contain vessels which later are devoid of them, viz.: the cornea, vitreous body, the anterior and posterior surfaces of the lens; and since the existence of vessels without doubt indicates a greater change of material, we can differentiate two periods of development and growth of the eye; the one of preponderating growth, the function not yet being established, as in fœtal life; the other of diminished growth, concomitant with the function of sight, as in extra-uterine life. This diminution of growth in tissues devoid of vessels, as opposed to those containing them, is most conspicuous in those parts whose nutrition is of the most apparent difficulty; for instance, in the lens, whose volume scarcely increases after birth, since the scanty reproduction of lens-elements is overbalanced by the diminu tion in volume of those already existing. The gradual inertia of nutrition in consequence of indirect nutrition is indicated, now earlier, now later, in a series of phenomena which we must regard essentially as retrogressive metamorphoses. The so-called arcus senilis of the cornea, the formation of the nucleus of the lens, the senile fluidity of the vitreous body, etc., are to be counted in this category. The formation of senile cataract does not belong here, to which we will recur in its proper place.

The difference between nutrient and nourished tissues, in connection with the fact that all nutrition finally depends on vessels, carries with it the fact that those parts supplied with vessels must also contain vessels for such tissues as are themselves devoid of them; therefore, the former are distinguished by a relatively greater quantity of vessels. Hence it follows that the current must be directed from parts supplied with, to others devoid of vessels. But the purely physical view leads to the same inference also. As a high pressure within the blood-vessels controls a less pressure without, so the direction of the current of fluids is essentially determined by the position of easiest exit. But since we know only the cornea and more especially the region of the ligamentum pectinatum as the places of a free exit, we arrive at the important conclusion that in general there is in the eye a current from behind forwards. This fact, which can be demonstrated by experiment,* is to a certain extent the basis from which our special study of the nutrition of the eye has to start; and it naturally follows that we must investigate the nutrition of the eye in the direction of this fluid-current from the posterior pole. The three great divisions as to nutrition, corresponding to the configuration of the separate parts of the eye, are as follow:

I. Choroid—retina—vitreous body.
II. Ciliary body—Petit's canal—lens.
III. Iris—aqueous humor—cornea.

This symmetrical triple division will be the basis of our observations. It has, of course, no absolute value, from the obvious necessity that there must exist an exit also from the vitreous body and the lens. A fourth division must, however, be added, embracing the vicinity of the canal of Schlemm and the corneo-scleral junction, because at this point the exit of all the intraocular fluids takes place, with a few exceptions, to which we shall recur later. The importance of this region, as well for operative purposes as for the pathology of the eye, justifies the discussion of this locality in a special section, which will call attention at the same time to the avenues of exit without the eye, so far as I succeeded in tracing their course.

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* Knies, Virchow's Archiv, LXV., p. 401 ff.

I. *Chorioidæa—Retina—Vitreous Body.*

The chorioidæa and retina are, so far as concerns nutrition, an inseparable unit. Like the pia mater and the cortex of the brain, to which the choroid and retina genetically correspond, the vascular and the nervous membrane of the eye form an indivisible whole. On account of the peculiar function of the eye differing from that of the brain, we see that the capillaries lie in the brain-substance itself, whereas they constitute a special layer without the retina. The most superficial observation of the chorioidæa, which membrane consists essentially of vessels with a sparing amount of connective tissue and unstriped muscular fibre, suggests that this abundance of vessels cannot have simply to subserve the purpose of its own nutrition. Their arrangement also leads to the same conclusion. The larger vessels lie chiefly outward, and the innermost layer is formed of the so-called chorio-capillaris, which is separated from the outermost retinal layer, or the pigment epithelium, by a thin membrane, called the hyaline. For the present, we may ignore the different lymph-spaces (Schwalbe, Sattler); these parts will be taken up in the fourth section. The process of nutrition is not materially modified by them, as will be further brought out.

The chorio-capillaris is distinguished by the narrow meshes and the large calibre of its capillaries, and fulfils all demands as to nutrition, which can be made by a tissue of such lively function as the retina. I desire especially to emphasize that the rich influx of arterial blood indicates a very great need of oxygen, and this appears to me to form, in part at least, the explanation of the lymph-spaces within the chorioidæa.

Since the arteries can supply oxygen only in common with the other elements of the blood, a correspondingly large amount of water and soluble substances must be given out also. It is very plausible to assume that this surplus is not conveyed through the whole eye, but is collected in the chorioidæa itself by the lymph-spaces and lymphatics, and in this way is disposed of. This would not prevent the full supply of fluid and solid matters to the outermost layers of the retina. We will return to this subject later.

While in a great number of vertebrate animals the whole retina is nourished by the chorioidæa, a second system of vessels obtains in most mammalia, viz.: that of the vasa centralia nervi optici et retinæ. In the horse, the capacity of the retinal vessels is confined to the vicinity of the papilla; in the hare and rabbit, to that portion where the layer of optic-nerve fibres is medullated; but in most of the remaining mammalia the system of retinal vessels extends over the whole retina, leaving free the region of clear vision, viz.: the fovea centralis. Capillary anastomoses exist sparingly at the entrance of the optic nerve, between the choroidal vessels and those properly belonging to the retina. The latter, with the whole fibrous layer of the retina, are formed later in fœtal life; just as the gray matter of the brain and spinal marrow is present earlier than the white. The vessels are so arranged in the retina that the larger trunks lie in the layer of optic-nerve fibres, while the capillaries extend as far outwards as the intergranular layer. The capillaries, especially when compared with the capillaries of the chorioidæa, are few in number and of narrow calibre; but we are not, therefore, at liberty to conclude that they carry little material for nutrition. Certainly oxygen is not largely furnished on account of the small amount of blood in the retina, but the transudation of a considerable quantity of fluid is proved by the fact that the retinal arteries are not accompanied by two veins as elsewhere, under similar conditions; further, by the narrow calibre of the capillaries producing a relatively strong vascular pressure. I regard this as direct proof that a relatively large quantity of fluid escapes the retinal capillaries—a condition well suited to the structure of the membrane.

From the position of the larger trunks, we may conclude that the percipient retinal elements must lie in its outermost layers; for, *cæteris paribus*, non-transparent objects, such as we must regard the vessels, are so much the less factors of disturbance the farther they lie from the sensitive layers. Moreover, the finer the vessels, the less can they intercept rays of light, and we find without the layer of optic-nerve fibres only vessels of a capillary calibre. From this it naturally follows that the general fluid-current of the retina is directed from without inward. Since the material of nutrition proceeds only from the capillaries, it is moved successively through all the retinal layers, uniting itself with newly escaping material, until it finally reaches the vitreous body.

We see, therefore, for the nutrition of the retina, two entirely independent and almost completely separate systems of vessels in activity, but which display the greatest possible difference between each other. While the outer system, that of the chorioidæa, is supplied by more arteries, contains capillaries of very wide calibre and very narrow meshes, and lies beyond the parts it goes to nourish, the other lies within its respective parts, has capillaries of narrow calibre and wide meshes, and preserves, as well *in toto* as in its individual branches, the character of terminal arteries (Cohnheim).

While in the former system a permanent interruption of the blood-current and of the nutritive supply from whatever cause is impossible, and obstruction of individual branches is compensated for immediately through the collateral circulation; in the latter, obstructions of any vessel, either the principal trunk or individual branches, are always irreparable on account of the impossibility of an immediate and sufficient substitution. A communication between the retinal and choroidal vessels exists only at the entrance of the optic nerve, but through connections which are purely capillary (Leber); only in this way a collateral circulation can take place. Until this occurs, however, the destruction in those retinal layers, the nutrition of which principally depends on the retinal circulation, is of such a character that the function of sight is permanently abolished on account of disturbed conductibility.

The demarcation of the provinces of nutrition of both systems of retinal vessels cannot be anatomically demonstrated; and the aid of pathological phenomena must be invoked. By these we learn with great probability that the outermost retinal layers—pigment epithelium, rods and cones, the *limitans externa*, and the external nuclear layer—are nourished essentially by the chorioidæa; that the retinal vessels are indispensable for the internal retinal layers, ganglion-cells, and layer of optic-nerve fibres; while the intermediate layers are supplied conjointly by both sets of vessels; so that, in case of necessity, sufficient nutrition could be secured from each. At all events, the choroidal vessels appear so far to supply the insufficiency of the vessels of the retina that for a long time no changes occur which are discernible by the microscope; while the same vicarious action on the part of the retinal vessels cannot as yet be proved, from easily imaginable causes, in case of a deficient supply from the chorioidæa.

We find in certain diseases of the retina which essentially concern the region of the retinal vessels—as, for example, embolism, glaucoma, atrophy of the optic nerve, etc.—after long continuance the two innermost layers, viz.: the ganglion-cells and layer of optic-nerve fibres, in a condition of atrophy; while the outer layers may remain microscopically intact, even after the eye has been blind for years. The reverse is much more difficult to observe, because with the destruction of the percipient elements the rest are equally destroyed; on the other hand, it is attested by one fact that portions of the retina which have lost their sensibility on account of choroidal changes may still possess conducting properties. The so-called *staphyloma posticum Scarpæ* of myopes, which causes only an enlargement of the blind spot, furnishes an analogous argument. In regard to the anatomical conditions, such as are met with in chorioiditis, compare Wecker in Graefe-Saemisch's Text-book, Vol. IV., Fig. 21, page 614, and Fig. 24, page 621.

These considerations lead us to the correct inference, that the retina, thus supplied by different, and at the same time independent regions of vessels, must indicate such diseases as fall either in the department of the choroidal vessels or in that of the *vasa centralia*. We should, therefore, classify the retinal affections as retinitis externa and interna; to the former naturally belong the different forms of chorioiditis, if for the present we disregard its suppurative types; to the latter, most of the forms known as retinitis. This division of the retinal inflammations—a division of the retina as a whole in two parts—is in no way artificial, as we shall presently discuss. The two divisions of the retina are differently disposed, so far as relates to nutrition, function, and origin. We must regard the outer layers as perceptive; and, analogous to the preponderating tendency of the choroid to inflame in circumscribed patches, these layers are likewise affected in circumscribed places. Every choroiditic patch of a certain size produces a temporary or permanent scotoma, as soon as the retina is drawn into the difficulty, which is by no means always the case. At the periphery these patches are not demonstrable, on account of their smallness and the obscurity of peripheral sight; but when their size is more remarkable, when they lie near the point of clearest vision, or when they are easily demonstrable on other grounds—for example, large staphylomata postica, as enlargement of the blind spot—a scotoma corresponding to the ophthalmoscopic picture can often be traced.

Since the conduction from sound parts remains intact, only a moderately reduced visual acuity is ascertained; because only where the chorioidæa, especially its capillary layer, is completely atrophied, the retinal elements are destroyed. Disease in the region of the choroidal vessels must, in the same way, be regarded as present in the so-called retinitis pigmentosa; the conduction remains intact, as cases prove in which the equatorial parts remain healthy, and a circular defect in the visual field is present. The hæmeralopia preceding the pigment degeneration, the torpor of the perceptive, not of the conducting retinal elements, points to the chorio-capillaris; the atrophy of the retinal vessels and the papilla corresponds to the loss of the perceptive elements, and must be regarded as secondary. Degenerative diseases in the vicinity of the retinal vessels furnish entirely different clinical pictures. A scotoma also is the functional result; but, corresponding to the arrangement of the conducting elements, it has more or less the form of a sector. To this category belong—not taking into account extraocular diseases, of course—embolism of a branch of the arteria centralis retinæ, contraction in the visual field in glaucoma, the angular defects of the visual field in atrophia nervi optici, etc.

It would lead us beyond our province to proceed further with details; and I content myself with the examples introduced, which, so far as concerns nutrition, sufficiently warrant the division of the retina into one part dependent on the choroidal, and into another dependent on the retinal vessels. Naturally both nutritive portions can be simultaneously diseased; yet, on account of the independence of both systems of vessels, this very rarely occurs, as experience shows, disregarding, of course, those affections which affect the globe in toto.

After the nutritive fluids have passed in the above-described manner from the choroidal and retinal vessels through the tissue of the retina, they arrive in the vitreous body. It is unnecessary here to enter upon a discussion as to the coarseness or fineness of the structure of the vitreous, as yet a very disputed point. It is sufficient to know that the vitreous body consists essentially of a tissue equivalent to intercellular substance, and the cell-contents are in the highest degree sparing. Of the three cell-forms described by Iwanoff (Zehender's Monatsblätter, 1864, page 420), the first may be conceived simply as wandering-cells, which, being found everywhere, are of course also in the vitreous body. Their number increases from behind forwards, and they exist in largest number in the vicinity of the ciliary processes. The two other kinds of cells have probably the same origin, but at all events are in more or less considerable degeneration of a fatty or mucous nature. Without doubt, the exceedingly small amount of cells leads to the conclusion of a very weak energy of nutrition on the part of the vitreous body, for which the fluid is sufficient which has in part already coursed through two membranes.

I may be here allowed to remark that the retinal vessels appear to me to be relatively more concerned in the nutrition of the vitreous body than has been hitherto supposed. The position alone attests to this; and it has been already noted that, on account of the narrowness of the capillaries, relatively more fluid must escape, with which also the singleness of the veins is in harmony. In further evidence is the fact that retinal vessels and vitreous body come from the same embryonic layer; and, moreover, that the embryonic vessels of the vitreous body originate in the art. cent. retinæ. A further proof, if it were allowed to adduce data from comparative anatomy, would be the so-called comb (pecten) in the bird's eye, and the occurrence of vasa hyaloidæa in the eyes of ophidia and fishes, whose retina is devoid of vessels (Leuckart in Graefe-Saemisch's Text-book, Vol. II., page 255). These structures can have no influence on the nutrition of the retina, since the fluid-currents in the eye are directed from behind forward. However, I do not wish to lay great stress upon this fact, since atrophy of the inner retinal layers exists without essential influence upon the vitreous body; and in a large series of animals, even mammals, there are neither retinal nor hyaloid vessels. The nutritive energy of the vitreous body is so weak, as is evident from its structure, that disturbances of its nutrition are first made apparent clinically by secondary affections in organs nourished by it, as the lens. The property of the fluid coursing through the vitreous body is not everywhere alike. At the posterior pole of the eye, where the retina is thickest and its function most energetic, a fluid of very weak nutritive power enters the vitreous body, because the principal quantity of its nutritive material is expended in the retina; for the further we proceed forwards, the less is required by the retina. The calibre and the number of the choroidal capillaries diminish, it is true, but not in the same proportion as the thickness of the retina. We must, therefore, grant that the vitreous body, viewed apart from the general fluid-current from behind forwards, is in like manner from behind forwards richer in nutritious matter; and, especially at the ora serrata, nutritive material passes from the choroidal vessels directly into the vitreous body. This consideration gradually leads us to the second part of our treatise, which has to do with the nutrition of the lens, and therefore it ought not to be further followed out here. But I desire briefly to call attention to one point, which, according to the foregoing statements, may be explained in the most simple way, namely: the senile fluidity of the vitreous body, which begins at the posterior pole. It also throws new light upon the so-called detachment of the vitreous body, since disturbances of nutrition must first become apparent in its posterior section.

If we should graphically represent the currents of diffusion of the fluids in the vitreous body, we would have a figure similar to the one represented by Hannover, which, it is said, corresponds to the structure of the vitreous in the horse's eye. I am, however, far from giving assent to the conclusions deduced therefrom, as to the membranous construction of the vitreous body; it is possible that such pictures appear after the successive influence of hardening agents.

The weak energy of the nutrition of the vitreous body is also in conformity with its passive behavior in inflammatory processes in the eye; it seems that all cells, pathologically present in the vitreous body, are derived from without. Similarly weak is its ability to withstand pathological proliferations, by which, without reaction, it is simply dislodged, and crowded towards the posterior pole of the lens. Without any functional disturbance, fluid can replace the gelatinous vitreous body, as is demonstrated by its so-called senile dissolution.

An independent disease of the vitreous body scarcely occurs, though I would not deny its possibility; compare the discussion of Coccius' paper on the Coarse Structure of the Vitreous Body (Zehender's Monatsblätter, 1864, page 323 ff.)—which, however, was published before the discovery of the emigration of white blood-corpuscles. Even to-day there is diversity of opinion as to the possibility of an independent inflammation of the vitreous body; but, clinical and experimental data render a passive behavior of the vitreous body much more probable. Diseases of the chorioidæa and retina induce, as experience shows, the great majority of the alterations found in the vitreous body.

Reviewing the conditions in the posterior segment of the eye, we note the following:

The choroid is the organ of nutrition for the outer layers of the retina, the retinal vessels for the inner; both regions of vessels are diseased independently, since no vascular connection exists between them.

Nutritive material enters the vitreous body only after its passage through the retina; the vitreous possesses a relatively weak energy of nutrition, and is capable of independent disease only exceptionally.

A general fluid-current exists in the vitreous body from behind forward, as in the retina, and passes through its intercellular substance—a fact hardly worthy of especial notice.

The vitreous body, on account of the diminishing thickness and ultimately complete discontinuance of the retina, contains more nutritive material in its anterior than its posterior parts; on this account, a diminution of nutritive energy begins in the posterior segment of the vitreous body.

Clinical observations, as well as the anatomical relations of the posterior segment of the eye, are in complete harmony with the above statements, which are in part demonstrated by experiment. Since all that has been said cannot as yet be proved by experiment, this harmony is very valuable and may in a certain sense be regarded as proof of the problem.

II. *Ciliary Body—Petit's Canal—Lens.*

A marked separation of this section of nutrition from the preceding is impossible, and does not really exist; nor can a sharp anatomical line be drawn. However, I have for the sake of comprehensiveness preserved this division, to simplify the discussion as much as possible. From the following segment—*i. e.*, iris, aqueous humor, and cornea—the division is anatomically better defined, though, as will be shown later, these two divisions also pass into each other as to physiological nutrition; because *the ultimate discharge of the whole waste of the nutritive material leaves the globe through the anterior chamber.*

The fluids which, arising from the choroidal and retinal capillaries, have served to nourish the retina and have entered the vitreous body, pressed by new exuded fluid, continue their forward course. As already explained in the preceding section, the anterior portion of the vitreous body is richer in nutritious matter than the posterior, and from the parts in front of the ora serrata retinæ, *i. e.*, parts of the ciliary body which lie behind the anterior wall of the canal of Petit, the current proceeds from the choroid directly into the vitreous. As the vitreous body contains almost no cell-elements, at least in the eye of the adult, the current from behind forwards cannot be essentially impeded, and the nutritive fluid enters the lenticular substance through the posterior capsule. The posterior wall of the so-called canal of Petit consists only of disconnected fibres (Merkel), but its anterior wall offers some resistance to the forward movement of the liquid. It is not as if this wall were impassable to fluids; on the contrary, it allows, as an animal membrane, free play to diffusion. Since we must admit the pressure in the vitreous body to be somewhat greater than in the anterior chamber, a considerable amount of fluid must pass directly into the aqueous humor; all the more, because no cellular layer stands in the path of diffusion. In spite of this, the diffusion through the anterior wall of the canal of Petit will not be so important as not to force a considerable portion of the fluid of the vitreous through the lens. The chemical nature of the zonula appears to exert a certain influence, for a layer of cells which would force the fluid to take its path through the intercellular spaces does not exist. Of great importance is the discovery of Kühne and Ewald (Digestion as a Histological Method, Transactions of the Society of Natural History and Medicine, in Heidelberg, Vol. I., part 5), that the capsule of the lens, like the membrane of Descemet, being digested with greatest facility, cannot be an elastic substance, as it was so long believed to be. Its behavior is like that of the interlamellar substance of the lens, which is dissolved before the lenticular fibres; and this would perhaps account for the origin of the capsule of the lens, not from apposition externally, but from the epithelial cells of the lens, analogous to cement-substance; and this undoubtedly occurs in Descemet's and Bowman's membranes.

If we inject yellow prussiate of potash into the middle of the vitreous body with the necessary precautions, and try to discover it after the lapse of a certain time by means of proper reagents, we find the principal part in the anterior segment of the vitreous and in the entire periphery of the so-called canal of Petit. From here it finds its way concentrically by the channels of the cement-substance into the body of the lens; this advance, however, is tolerably slow, and in rabbits does not exceed one-sixth of the thickness of the lens in four hours (Knies, Virchow's Archiv, Vol. LXV., page 401 ff.). That, in my experiments just quoted, the most intense staining of the lens was observable at the posterior pole, was the result of the fact that the injection was always made with tolerable accuracy in the centre of the vitreous body, the salt seeking the nearest way towards the posterior pole of the lens. In the posterior segment of the globe a staining was manifest, and in the retina and chorioidæa of the anterior segment only so much as could be attributed to simple diffusion during the slow motion of the current; the exception to this and its explanation follow in the fourth part. The above experiments attest, first, the real existence of a fluid-current in the eye from behind forwards, and, secondly, furnish an approximate estimate of its velocity. The velocity of the current appears in general to be greater in the vitreous body than in the lens; or, in other words, the whole fluid which proceeds from the vitreous body into the anterior chamber does not take its way through the lens. This is also very plausible. In order to get into the anterior chamber, the fluid must, on the one hand, be simply diffused through the anterior wall of Petit's canal; while, on the other, the very sparing intercellular substance of the lenticular fibres are of service to this end. If we reckon the time requisite for the passage of a single molecule through the lens, the minimum amount devoted to the passage through the rabbit's lens is twenty-four hours. This seems to be a very long time: but I think that in reality, especially in man, a considerably longer time must be admitted. The experiments of Memorsky (Graefe's Archiv, Vol. XI., 2, page 112 ff.) furnish additional testimony. He was able to recognize ferrocyanide of potassium, injected into the blood, in twenty to sixty minutes in the aqueous humor, and still later in the vitreous body, but not at all in the lens. All the salt, it is true, had completely disappeared in eight or nine hours. Other subtances (lithium) were demonstrable in the lens last of all.

Only under the supposition of this slow nutrition is it possible to imagine that the lens increases in such a relatively slight degree from birth to manhood, as is certainly the case. Since the new-formed fibres are not destroyed, either on account of fatty or any other degeneration, nor thrown off, as perpetually occurs with the epidermis, but only shrink moderately, the relative constancy of the size of the lens is explained in this way.

Where epithelial cells are locked up in other places of the body, but under better nutritive conditions, remarkable increase in number and size follows; as we see, for example, in an atheroma. Only where nutrition is at the minimum is it possible for the cells of the lens to preserve in their different transformations one essential property—their transparency; and with the slightest irregularity in growth the form of the lens must necessarily suffer, whose regularity constitutes so important a factor in its functions. The more lively the growth and the phenomena of nutrition in an organ are, the more easily must changes of form occur, even by inconsiderable irregularities. But the lens, as follows from the preceding, does not receive the same amount of nutrition in all places. The vitreous body must be richer in nutritive material in its anterior peripheral segment, especially in the vicinity of the ciliary body, than in the centre. Fluid enters at the posterior pole of the lens, which has lost certain substances while passing through the retina and vitreous body; towards the equator of the lens this fluid is more nutritious, and at the equator itself must be the most active. The fact that the diameter of the thickness of the lens hardly increases in extra-uterine life tallies with the preponderance of nutrition at the equator. Waste in the centre and reproduction in the cortex are pretty nearly balanced. On the other hand, the transverse diameter of the lens increases considerably, and the crystalline body changes, in consequence, from the shape of a sphere into that of a lentil (lens). At all events, with these phenomena of growth, the absolute distance of the lens from vascular nutrient tissues is of moment.

The smaller the eye as a whole, the easier and better is the nutrition of the lens. Since the growth of the lens does not keep equal pace with that of the eye *in toto*, but falls behind, a correspondingly greater part of the fluid of the vitreous body must pass directly through the anterior lamina of the zonula Zinnii into the anterior chamber without previously passing through the lens.

Since formed particles do not normally penetrate the lens, and in pathological cases are found only after a rupture of the lens capsule (consult Julia Sinclair's " Experimental Inquiries into the Recovery of Acquired Capsular Cataract," Inaugural thesis, Zurich, 1876), we may disregard undissolved substances in the question of the nutrition of the lens.

In correspondence with the slight consumption of material in the lens is a change of the central parts in advancing years, the so-called formation of the nucleus. In the fœtus and in early youth, when the nutritive conditions of the lens are relatively favorable, when the distance from vascular tissues is less, and the whole organ smaller, there is nothing of a nucleus to be seen; but later, the central parts of the lens experience a peculiar change, which shows a marked analogy to the sclerosis of other epithelial cells, and is often identified with it, though the chemical alterations are not in accordance with this supposition.

The formation of the nucleus begins in the most insufficiently nourished centre of the lens, and the consequent shrinkage of the parts involved is the occasion of so slight a change in volume. The lenticular fibres involved in the formation of the nucleus possess a great resistance to pathological changes, and hence the assumption may be justified that they are excluded from the series of the lens-elements requiring nutrition. Beyond the amount of fluid necessary to preserve their moisture and transparency, they require hardly any other nutritive material, and allow the latter to be entirely consumed by the as yet unchanged cortical fibres and equatorial cells. At the equator alone, there exists, under normal conditions, until the latest period of life, sufficient nutritive material to preserve cells capable of life and division; as soon as the newly-formed lens-fibres, by growth from behind, are pushed somewhat from the lens-capsule, they begin to change. The nutritive energy, diminishing with the increase of age, is the cause of the relative growth of the nucleus at the expense of the cortex, whose absolute quantity becomes constantly less.

Hence we see that the parts of the lens, which differ anatomically and histologically, differ also in their physiological nutrition. The most favorable position for nourishment in the nearest proximity to the corresponding vascular tissue is occupied by the formative cells at the equator. The lens-fibres, containing globulin, are, on account of their position in the vicinity of the capsule, through which nutritious fluid enters, likewise capable of nutrition, and of undergoing pathological changes. The fibres of the nucleus have undergone degenerative metamorphosis of slight degree, probably in consequence of deficient nutrition; and therefore the formation of the nucleus begins at the greatest distance from the nutrifying membrane. Since the attachment of the zonula Zinnii extends considerably forwards towards the anterior pole of the lens, the anterior cortex lies in a relatively favorable position, especially when the whole stream of fluid is taken into account. Nevertheless the anterior cortex in the vicinity of the anterior pole of the lens appears to be a *locus minoris resistentiæ*, to which the formation of a cataracta polaris anterior in non-central corneal perforations seems to attest. Further, it seems to me that many other anterior polar cataracts can be explained more easily and simply, by the single fact of relatively unfavorable conditions of tissue-change, than by a problematical fœtal perforation. It is self-evident that their formation is favored by a central perforation of the cornea, or a continued contact with the posterior surface of the cornea; that the attachment of the zonula may be of importance in the development and extension of cataracts, is demonstrated by a case lately published by me (Graefe's Achiv, Vol. XXIII., part 1, page 211 ff., and Figs. 1 to 5, Plate III.).

The slow appearance and progress of lens-diseases corresponds with the remarkably slow fluid-changes. In general we may assume that every change of position of the lens leads, sooner or later, to opacity, *i. e.*, formation of cataract. Very much, of course, depends on the amount and direction of the dislocation. Since the diffusion of nutritive fluid is made difficult by the sparing intercellular substance of the lens, and its complete saturation occurs only through the difference of pressure between the vitreous body and anterior chamber, it follows that rupture of the partition-wall between the two leads to disturbances. My remarks refer only to the lens, enclosed in an unbroken capsule, and I will not take further notice in this article of the appearances when the latter is open. The beginning of the opacity, after the rupture of the capsule, depends so very much upon accidental circumstances, that we are at a loss to lay down fixed rules in regard to it; agglutinations with the wall of the globe hasten the formation of cataract. The late and tardy development of cataract, for instance, after many months, as is so often observed, corresponds to the slight tissue-change in the lens; it is to be remarked here that by a rupture of the partition-wall between the vitreous body and anterior chamber the circulation in the vitreous must necessarily be hastened—a circumstance which can in part restore to the lens the advantage which it enjoyed in its natural position.

Since we have regarded the chorioidæa and the whole uveal tract backwards from the anterior wall of Petit's canal as the tissue whose vessels supply, among others, the nutrition of the lens, it still remains to bring clinical and pathological facts into harmony with this idea. On account of the fact that the lens, in regard to physiological nutrition, depends on other tissues, diseases of the latter must introduce disturbances of nutrition in the lens. This refers especially to those forms of cataract which come under observation with a capsule intact and a normal position of the lens. Of one form it has been known for a long time, that it stands in causal connection with affections of the chorioidæa; namely, the posterior cortical cataract, which therefore is sometimes spoken of as choroidal cataract. This form of cataract shows us that the posterior cortex is affected by diseases of the membranes in the posterior half of the globe, recognizable by means of the ophthalmoscope (chorioiditis disseminata, retinitis pigmentosa, etc.). If now, as is usually accepted, the posterior cortex is connected with the chorioidæa behind the ora serrata, a form of cataract, beginning at the equator, indicates, by the relations of the current here proposed, an affection of the portions of the uveal tract situated before the ora serrata and behind the anterior lamella of the zonula Zinnii, the pars ciliaris retinæ, and the ciliary processes. This is the ordinary senile cataract, the formation of which does not seem to necessitate very marked changes in the uveal tract (colloid bodies?); these would have long ago come under observation. But we might imagine an insidious chronic affection, perhaps an induration, or only a premature atrophy of the parts concerned. Since in consequence of this, the most important part of the lens, namely, the equatorial formative cells, is affected, it is obvious that slight causes may produce great results. This idea, independently of the anatomical position and everything that has as yet been referred to in this paper, is corroborated by certain appearances, which are regarded as prodromi of a senile cataract, and can with propriety be referred to the ciliary body—as premature presbyopia and increase of refraction. I know very well that these can be located directly in the lens as the initial step in the formation of cataract.

But more important is the fact that some authors consider convulsions to be causes of cataract. Convulsions exert an influence on the lens only through the ciliary body. Not long since, I had the opportunity of directly observing that convulsions of the ciliary muscle do occur at least in epilepsy, and communicated this fact to the Ophthalmological Convention at Heidelberg, in 1877 (compare the Report, page 61). In fact, convulsive attacks are a generally accepted cause of the origin of lamellar cataract, provided we imply no direct spasm of the ciliary muscle, but rather convulsions elsewhere. Senile cataract takes its origin in the equator of the lens, corresponding to the ciliary body, with the same regularity as obtains in the beginning of choroidal cataract in the posterior cortex. This constancy in the parts first affected leads to the conclusion that a certain definite tissue gives rise to a definite form of cataract. The uveal tract anterior to the ora serrata, which is chiefly concerned here, unfortunately is just that part of the eye which interposes insurmountable obstacles to examinations *in vivo;* hence this question can be solved only by pathologico-anatomical investigations.

It is very difficult and only exceptional to procure the necessary material; so that a final conclusion may be arrived at only under fortunate conditions. The investigation of the, at the present time somewhat neglected, anterior segment of the uveal tract, the part not accessible to the sense of sight, may lead to the satisfactory solution of many hitherto open questions; it is, however, much more difficult, since it cannot be verified by direct observation.

The appearances of the lens-elements in the formation of cataract correspond remarkably to the picture of parenchymatous inflammation, as described by Virchow. We have, as in kidney-epithelium, opaque swelling (albuminous infiltration); then follow fatty degeneration and disintegration and destruction of the fibres (detritus); then their absorption, which, however, remaining incomplete from the slow tissue-change within the lens-capsule, leads to partial inspissation; finally, to complete the similarity, regenerative processes supervene in the undisturbed elements.

If the appearances of the vascular interstitial tissue, which is not found in the lens, were present, the identity of both processes would be complete. Even a hyaline membrane, analogous to the lens-capsule, between vascular connective tissue and epithelial cells, is, for instance, found in the kidney. If we could conceive of the lens and ciliary processes, in the light of physiological nutrition, as a single organ, and if the appearances of a chronic, interstitial inflammation in the ciliary processes could be demonstrated, the analogy would be perfect. Further evidences are:—the formation of senile cataract is always to be regarded as a pathological process; further, the age, in which in other organs also such inflammations appear with preference; and the occurrence of cataract in diseases which dispose to parenchymatous and interstitial inflammations of other organs (diabetes). With the present theories of inflammation, however, this stands in rather bold contradiction. It is enough for me, without indulging further in theoretical speculations, to have hinted at the complete analogy between the appearances of the lens-fibres in the formation of senile cataract, and those of epithelial cells in the so-called parenchymatous inflammation; the name is nothing to the purpose. Since decay of lens-substance is observed in every true cataract, the opacity could only disappear, if the detritus were brought into complete absorption; but it is easy to conceive that in the lens this would meet with peculiar difficulties. This absorption proceeds very slowly under normal conditions and is never complete; furthermore, the function of the lens would seriously suffer on account of its irregular surface (capsular cataract). On the other hand, we can readily imagine that, at the beginning, when the opacity may be regarded as due to a dislocation of lens-elements on account of serous infiltration, the opacity may disappear again in case it has arisen from a temporary cause, as diabetes. Resolution is also possible in the stage of opaque swelling (albuminous infiltration), after the analogy of parenchymatous inflammation. Such an occurrence, however, is very rare in clinical experience, probably, because a *long-continued disturbance in another tissue precedes* the formation of the cataract, and cannot be altered in its course. Although we might, by injections into the vitreous body, artificially introduce certain substances in the lens, and hasten the movement of fluid in the lens by puncture of the anterior chamber, it is impossible artificially to produce transparency in a cataract more or less advanced; and so much the more, as we must assume that the cause cannot be eliminated.

I am far from the idea of making the chorioidæa or ciliary processes responsible for every opacity of the lens, which seems true only in regard to the two well-characterized forms of cataract, the choroidal cataract beginning in the posterior cortex, and the senile cataract taking its origin at the equator, as well as certain kindred forms which appear in early years of life. Opacities of the lens from other demonstrable causes (for example, anterior polar cataract, anterior synechia, etc.) tend much more to remain stationary; so, too, those opacities in which we find a temporary alteration of the nutrient tissue (lamellar cataract). Opacities in cataracta polaris posterior are wont to remain stationary for a longer time, and to progress more slowly than those beginning at the equator, where the phenomena of life are more active. Associated with the physiological formation of the nucleus are a moderate shrinkage, darker color, a greater refraction of light, etc.; more light is absorbed in the lens, when it becomes yellow and brown, but a true opacity due to separate particles is not associated with the hardening of the nucleus. Were it possible to conceive of a normal, final stage in the growth of the lens, it would be exemplified by certain forms of so-called cataracta nigra, in which the nucleus had occupied the whole lens. The rarity of this form of cataract leads us to infer that it owes its formation to pathological influences which are the direct result of the premature occurrence of a condition not normally attained even in the latest years of life. Since we must regard the formation of a cataracta nigra as the result of a prematurely deficient nourishment, that is to say, a true degenerative process, we must assume a certain irritation and increased supply as the cause of true cataract, since the equatorial cells and the anterior epithelium not only persist for a long time, but are, in later stages, capable of processes of proliferation (capsular cataract, or the so-called crystalline ring). The swelling of the lens, observed at the beginning of cataract formations of rapid growth, is explained in the same way. We must therefore consider as the most important points in the nourishment of the lens the following.

The nutrient fluid of the lens originates in the chorioidæa and parts of the ciliary processes; the choroid bears an intimate relation to the posterior cortex, the ciliary processes to the equatorial cells.

The fluid-current takes place within the very sparse interstitial tissue, and proceeds in general from behind forwards.

The normal senile changes in the lens (formation of the nucleus) are to be regarded as results of insufficient nutrition, and, consequently, appear first at the centre.

Since the lens depends completely on other tissues for its nutrition, it is more than probable that all so-called spontaneous opacities of the lens take their origin without the lens, and that especially for ordinary senile cataracts the first cause is to be sought in the ciliary processes.

Under these suppositions, attempts at clearing up a cataract artificially must be regarded as hopeless, although the exceptional occurrence of a spontaneous clearing up of a cataract (specially in diabetes), is proved beyond a doubt.

III. *Iris—Aqueous Humor—Cornea.*

Whereas the literature relating to the previous section was very meagre—with the exception of the isolated and scattered remarks which I specially found in O. Becker (Graefe-Saemisch

Vol. V., page 157 ff.), and of my own experiments (Virchow's Archiv, Vol. LXV., page 401 ff.), there properly belong here only Memorsky's communications, which have an essentially negative bearing on the lens (Graefe's Archiv, Vol. XI., 2, page 112 ff.)—the literature for this chapter begins to flow somewhat richer. Disregarding, however, the numerous papers on intraocular pressure, which do not properly belong here, there remain only a few contributions, and these Leber has compiled in Graefe-Saemisch, Vol. II., pages 391 and 392, up to 1874. To these papers are to be added, out of the number of those of later date, one by Leber himself (Researches on the Interchange of Fluids in the Eye, made together with Dr. Krükow, Graefe's Archiv, Vol. XX., 2, page 205 ff.), and one of mine (Absorption of Blood in the Anterior Chamber, Virchow's Archiv, Vol. LXII., page 271 ff.),

If soluble yellow prussiate of potash is injected into the anterior chamber under the necessary precautions, and after suitable time an examination is made, the salt is found, provided the experiment be interrupted sufficiently early, not only in the aqueous humor, but also in the cement-lines of the epithelium of the membrane of Descemet, in the latter itself, in the membrana propria of the cornea, especially in its inner layers, and even, though sparingly, in the cement-lines of the anterior epithelium. The quantity of salt increases towards the corneal periphery, especially toward the scleral junction, while the blue color produced by the chloride of iron is finally lost in the subconjunctival tissue. If the examination is made later, the aqueous humor is free from ferrocyanide of potassium (in the rabbit after three or four hours), while the salt is still found in the other localities. Posterior to the above-mentioned structures (iris and capsule of the lens), either no blue staining takes place, or in such slight degree that it can easily be attributed to simple diffusion, contrary to the natural direction of the current. These are essentially the results of my experiments, *loco citato* described, on the course of soluble and diffusible materials introduced into the anterior chamber; let us see how they correspond with the experiments of others.

So far as the origin of the aqueous humor is concerned, it is to be remarked that, in general, the ciliary processes, perhaps also the posterior surface of the iris, lay claim to it.

Leber has ascertained (l. c., page 89), that at least *the larger part* of the aqueous humor is secreted in the posterior chamber, in contradistinction to the anterior chamber, that is, the anterior surface of the iris. My experiments also are in complete harmony with this. It necessarily follows, however, from the facts stated in the preceding chapter, that this can be only a part, though probably the larger one. An important portion of the aqueous humor is fluid, which, originating in parts lying behind the zonula Zinnii, has already served for the nutrition of different tissues. Consequently there is in the aqueous humor a collection of fluid secreted by the whole uveal tract. It is difficult to estimate, even approximately, the relative amount secreted anteriorly and posteriorly to the zonula. It seems to be certain that the pressure in the vitreous body somewhat exceeds that in the aqueous humor; just how much is not yet accurately determined. This is easily explained by the continual exit of fluid which takes place from the anterior chamber, the vitreous body being separated from it by a membrane which establishes a certain opposition to its passage. Further, it is certain that the fluid-current is slower in the vitreous body than in the anterior chamber; this is evident from Memorsky's and my own experiments. By the former, even the proportion can be nearly determined; the velocity of the current in the aqueous humor, compared with that in the vitreous body, would average the proportion of 9 to 2; and this seems to me to be not far from the truth of the case. Hence, the share of the component parts of the aqueous humor might be computed, but such conjectures, resting as they do upon somewhat uncertain premises, have no further value.

For the present, let us hold that the aqueous humor is not a simple secretion or a transudation from the ciliary body and the posterior surface of the iris, but that an important part of it is made up of fluid which takes origin in the rest of the uveal tract and the retinal vessels. That the puncture of the anterior chamber, by which we can hasten the transudation of aqueous humor, influences the rapidity of the circulation in those parts of the eye lying behind the zonula, I have proved by experimental evidence. If the vitreous body of each eye of a rabbit is injected at the same time with an equally small quantity of a solution of yellow prussiate of potash, and if the anterior chamber of one side is punctured, it may be proved that the salt advances, in the same interval of time, more deeply in the lens of the punctured eye. And ferrocyanide of potassium can be demonstrated in the anterior chamber, and even in the cornea of the punctured eye, when at the same time no trace of it is to be found in the same localities of the other eye.

It is not easy to make a positive statement in regard to the rapidity of the secretion of the aqueous humor; but the rapidity does not appear to be very great. It is well known, that in children puncture is followed in a few minutes by a refilling of the aqueous humor. From this, however, it is not possible to draw a conclusion, since a much more rapid secretion follows a sudden diminution of pressure; besides, it is well known that punctures change the chemical character of aqueous humor very rapidly, rendering it albuminous. At best, we might estimate from the duration of the same process in older individuals a ratio of the relative velocities at different ages—an examination, which would be sufficiently important to be made. Memorsky's experiments are more directly conclusive. He found that, after one injection of a dose of ferrocyanide of potassium into the blood of a dog, the salt appeared in twenty minutes, and disappeared, at the latest, in eight to nine hours. The renewal of the aqueous humor in the dog cannot take place sooner than in eight hours. My own experiments on rabbits proved that ferrocyanide of potassium, brought directly into the anterior chamber of a living rabbit, disappeared in three to four hours under the most normal relations of pressure. And since the pressure in the chamber was, in my opinion, too low rather than too high, I would count the actual time for the rabbit somewhat greater. As with Memorsky the salt circulated a longer time, and consequently was secreted for a longer time in the anterior chamber, eight hours must be considered as very much too long a time. With due regard to all conditions, a period varying from four to five hours may be assumed as the necessary time for a complete renovation of the aqueous humor of a rabbit. This seems to be rather a long interval; but we can easily understand it, if we bear in mind the proportionate difficulty of escape of the fluids.

If the animal is dead, the eye removed, and the vessels are empty, the escape is somewhat easier. The experiments of Leber on the escape of fluids, after filling the blood-vessels with hardening agents, must be cited here. In the living individual, the vessels are filled, and in the places where the interchange between blood and tissue occurs, the capillaries, a current from the interior of the vessels into the tissue takes place. The thickness of the venous walls renders the direct passage of fluid into the larger veins almost impossible. Escape can only occur through the lymph-vessels, in case the vessels and capillaries are not empty, as in the dead animal, or there is no pressure in them. The difference in velocity of filtration between injected and non-injected vessels is very remarkable; and it even makes a difference whether the dead eye is enucleated, or remains in the orbit (Leber, loc. cit., page 122).

The origin of the aqueous humor being determined, and its continued escape being explained, the question of its direction comes before us. Schwalbe regards the anterior chamber simply as a lymph cavity, and admits the existence of a direct communication by means of vessels. Leber deserves great credit for having satisfactorily demonstrated the falsity of this view (Graefe's Archiv, Vol. XIX., 2, page 87 ff.). There is nowhere a direct communication by means of blood-vessels. All attempts at injection with approximatively normal pressure prove that no current from behind exists, whether the coloring matter (ferrocyanide of potassium) is directly or indirectly applied; the experiments of Leber agree with my own in this regard. If we study the anatomical construction of the anterior wall of the aqueous chamber, we find it to consist of a single layer of scaly epithelium and anterior to it a so-called vitreous membrane, which, toward the insertion of the iris, partly divides into fibres, and is less completely lined with epithelium. This fact alone leads us to look for the escape of the aqueous humor in Fontana's space; and it is certain that this locality is of great importance in the removal of the aqueous humor. *Escape does not take place here alone, but the whole cornea participates in it in such a way that the nutrition of the cornea is at the same time almost wholly derived from the aqueous humor.*

Until quite recently it was the current opinion that the cornea is nourished by the anterior chamber (compare Leber, loc. cit., page 125 ff.). It was essentially based upon clinical facts, but the so-called drop-experiment was also cited in evidence. Leber has demonstrated that the penetration of fluid through the cornea and its presence in the form of drops are to be regarded merely as cadaveric phenomena, and do not take place when the epithelium of Descemet's membrane is intact, even under very remarkable pressure (as high as 200 mm. of quicksilver). As is well known, the corneal substance becomes very much swollen and opaque in aqueous humor, and Leber saw in the coating of endothelium a protection of the cornea from the infiltration of the aqueous humor. Though Leber finally refused to admit a total impermeability of this endothelial layer for fluids, the nutrition of the cornea from the anterior chamber must, according to his experiments, almost fall to the ground, yet at the same time, *under pathological conditions*, he acknowledges a copious infiltration of aqueous humor into the cornea (compare his paper in the Ophthalmological Society of Heidelberg and the debates on it, Sept. 4th, 1871, in Zehender's Monatsblätter, Vol. IX., page 365 ff.). His communications at that time and his later publications (Studies on the Interchange of Fluids in the Eye) produced a great sensation, and gave me the incentive to examine, at the request of Prof. Kühne, the behavior of solutions introduced into the anterior chamber. I arrived at the results already given above. Since the correctness of the results observed and communicated by Leber is not to be doubted, it is of importance to explain the apparent contradiction of facts. Above all things, we may conclude that, if fluid penetrates into the cornea, abundant provision is made for its continuous escape into the subconjunctival tissue. Moreover, Leber has very properly emphasized the difficulty of passage of fluid into the cornea through the posterior epithelium. If we look for the parts through which the fluid passes in the cement-lines, we find them between the endothelial cells; further, the interstitial tissue of the cornea, which is analogous to intercellular substance, is saturated with the solution used. The absorbing surface is markedly limited by the impassable cell-protoplasm in proportion of the surface of cells to that of cement-substance, which is very much smaller. Since the proper substance of Descemet's membrane and of the cornea easily imbibe the salt solution, the consequences of a removal of the endothelial coating are apparent, and exactly as given by Leber. I am inclined to regard the endothelium of the membrane of Descemet not an obstacle for the penetration of fluid into the cornea for the purpose of nutrition, but certainly as a regulator. In consequence of the impassableness of the protoplasma, only so much can penetrate as is possible without disturbance of function. It has often occurred to me whether increased pressure cannot press the cells somewhat flatter, and thereby reduce the level of the fluid-absorbing cement-substance. The increase of transudation by increased pressure would be neutralized by a reduction of the absorbing surface. The conditions under a considerably increased pressure are thus very well explained; I doubt, however, if such a behavior of the cells can be demonstrated; at all events, this relation deserves a proper examination, for which I am at present unprepared.

The nutritive canals of the cornea serve as conduits; they communicate with those of the sclera and of the subconjunctival tissue, as well as with lymphatics, and hence are in position to promote a considerable amount of fluid. If they are compressed, as must always happen when the cornea is bound upon a pipe for the purpose of experiment, a remarkably abnormal relation obtains by reason of the impossibility of escape. In consonance with this fact, Leber has found that the impassableness of the cornea is more certainly proved—"the results were more negative"—when increased pressure was made by the introduction of a canula into the eye otherwise uninjured, than when the cornea was bound down (loc. cit., page 148). Of course, in the second case, escape towards the periphery was prevented, and filtration sooner supervened. But by the simple experiment that solutions, introduced into the anterior chamber under normal pressure, penetrate the cornea with the greatest facility, although not very rapidly, even between the cells of the anterior epithelium, the course of the fluid-current, actually present, is indicated; and with this harmonize also clinical facts.

Since the whole surface of the cornea is receptive, and the current is directed towards the periphery and towards the efferent lymphatics, a certain heaping-up of the salt introduced must take place towards the corneal border. This was apparent in my experiments, as in those of others, and necessarily led me to the question of the permeability of the cornea from without inward. It is proved that materials pass into the anterior chamber through the cornea; I allude here, as always when otherwise nothing special is said, only to experiments on the *living* animal. The entrance is not very active, as is evident from the natural fluid-current; relatively strong solutions must be dropped in often (a drop of a one-per-cent solution of atropine is half of the maximum dose for an adult to take internally). In spite of this, the proof of penetration into the chamber failed in certain experiments (Memorsky). Under these conditions, the fluid enters likewise by way of the interstitial substance (negative pictures of the corneal corpuscles), and is greatly accelerated by removal of the anterior epithelium.

The results of certain other experiments coincide with my supposition of a centrifugal current of nutrition in the cornea. Wysotzky found (Leber and Krückow, Graefe's Archiv, Vol. XX., 2, p. 213) that atropine acts the more quickly, the more centrally it is applied to the cornea; if introduced into the conjunctiva, the mydriasis appears simultaneously in the two eyes, and only after a longer time, therefore, as a general manifestation. Laqueur found that, by introduction of ferrocyanide of potassium into the anterior chamber, the marginal gave a reaction earlier than the central portion of the cornea. These two results can only be explained by assuming a centrifugal fluid-current, from which it follows that the nutrition of the cornea cannot take place from the periphery through the marginal vessels, but only from the anterior chamber. It would be difficult to conceive, if we are convinced of the impassableness of the posterior epithelium of the cornea, how nutrition can take place from the border, because an escape must take place also. Since the inner and outer epithelium establish an obstacle to transudation, this could be explained only on the supposition of currents in the cornea, which must run diametrically opposite to each other.

The nutrition of the cornea, therefore, takes place from the anterior chamber, the nutritive fluid penetrating between the endothelial cells and saturating the *substantia propria* of the cornea. The *escape occurs* toward the periphery, that is, *towards the subconjunctival tissue*, and is probably aided by the nutritive canals. From all experiments it results, that the nutrition of the cornea is in no sense very rapid or abundant, which was not to be presupposed from its weak energy of growth. On the contrary, if the afflux were too profuse, the function of the cornea would be endangered by swelling and opacity (destruction of the posterior epithelium). But only an inconsiderable amount of aqueous humor passes through the cornea. Fluid can escape at the insertion of the iris and the position of the ligamentum pectinatum, without having previously passed the cornea; and just here, according to all experiments and experience, a relatively free exit appears to take place, owing to the incomplete endothelial coating of the parts concerned, since a direct communication with vessels does not, as Leber has shown, exist. Although these relations of an easy outlet at the insertion of the iris are proved, they have not been established with sufficient clearness.

It is natural to presume, on account of the presence of a current, whose general direction is towards the periphery, that the centre of the cornea is, in a certain sense, a locus minoris resistentiæ, to which also certain clinical facts give evidence.

The fluid-current in the cornea, always slow and scanty, suggests that its superficies quickly dries, if it is not continually moistened ; on account of the difficult relations of diffusion, fluid cannot so quickly flow in as it evaporates from the superficies —a condition impossible of occurrence in a less difficult manner of nutrition.

Although it is proved, without doubt, that soluble substances *can penetrate* the cornea from without into the anterior chamber, I am loth to attach any worth to this circumstance for the nutrition of the cornea. Fluid within and without the cornea does not manifest the necessary difference of composition to enable it to overcome by diffusion the tissue-current of the corneal substance. It replaces, probably, only what is lost through evaporation; and, corresponding to this, in the absence of moisture from without, we do not find the cornea in a state of necrosis or broken down by ulceration; but the epithelial layers dry up, just as everywhere occurs on the skin, whose epidermis is analogous to the epithelium of the cornea. I regard it possible, and even probable, that absorption from without can take place of one nutritive substance only, atmospheric oxygen. It is well known that gases are the only agents which pass through the uninjured epidermis in any considerable quantity; and, since we may reasonably believe that in the difficult nutrition of the cornea its outer layers cannot be too abundantly supplied with oxygen, the cornea offers no greater obstacle to its absorption than mucous membranes not belonging to the respiratory tract, of which it is well-known that they absorb oxygen.

All the remarks hitherto made apply only to soluble *diffusible* materials. A transmission of indiffusible agents (Prussian blue) from the chamber into other tissues appears, according to Leber's experiments, impossible. I was unsuccessful in these experiments from another reason. The starch used for this purpose was destroyed on account of very rapid fermentation in diffusible agents. But, since transmission in the cornea depends on the chemical constitution of the membrane in question, and, as stated by Leber, the substantia propria of the cornea, in the living condition, is antagonistic to *coloring materials*, I am *not* disposed to conclude, from its behavior to Prussian blue, that it is *necessarily impassable for all colloid materials*. On the contrary, if a starch-solution is injected into the corneal tissue itself, the substantia propria becomes filled with it, and is colored deep blue by iodine. Since this substantia propria and the cement-lines of the posterior epithelium are analogous, their passableness for colloid materials seems very probable, perhaps not equally for all agents, and perhaps more slowly than for the crystalloids. The well-known experiment of Riesenfeld, the injection of a mixture of so-called soluble Prussian blue and carmine into the anterior chamber, apparently militates against the exit of indiffusible subtances from the anterior chamber. If we bear in mind that Prussian blue is rapidly decolorized in the alkaline tissue-juices, we can no longer regard this, otherwise very pretty, experiment as corroborative proof. On the contrary, hæmoglobin, which is equally indiffusible, surely passes from the anterior chamber into the subconjunctival tissue, as the frequent cases of yellow and yellowish œdema from hemorrhages into the anterior chamber prove.

The marginal vessels of the cornea are destined for the normal nutrition of a circumscribed portion of its limbus, which extends at the furthest two mm. towards the centre. This relation is not directly proved, but follows necessarily from the phenomena of nutrition hitherto described, and from certain conditions that are more or less pathological.

We have therefore—to repeat once more—two territories of nutrition in the cornea; 1. the marginal portion, one to two mm. broad (but this is mostly superficial); 2. the much greater central part, whose nutrition takes place from the uveal tract through the intervention of the aqueous humor. Where these two regions come in conjunction, there is necessarily the least energy of nutrition, a locus minoris resistentiæ must exist. and as such the corresponding marginal portion of the cornea has been for a long time clinically known (annular ulcer, etc.).

There also sloughing takes place in necrotic processes of the cornea.

In opposition to this I have lately observed a case, where, after a severe injury with rupture of the sclera, and complete tearing away of the iris and lens, a central persistent opacity of the cornea supervened, which left a transparent margin to the extent of about 1½ mm. Only at the point where the rupture of the sclera was nearest to the cornea, a projection of the opacity advanced to the margin; elsewhere the opacity was cut off tolerably sharp with a somewhat irregular contour towards the perfectly transparent corneal margin. I did not know how this could be explained otherwise than by the mode of corneal nutrition above described. It is possible that the tearing away of the iris was of importance; but a total laceration of the iris is not usually accompanied by such a corneal opacity. The occurrence of the so-called arcus senilis is also explained in a very simple and entirely satisfactory way. Since the main trunks of the lymphatics lie at the inner and outer margins of the cornea (Waldeyer in Graefe-Saemisch, Vol. 1, pp. 248), in diminished energy of nutrition a more rapid current must take place inward and outward than above and below. The degenerative phenomena, originating between the two regions of nutrition in the cornea, must appear most readily on the upper and lower corneal margins. Hence, the arcus senilis, a fatty degeneration of the substantia propria and corpuscles of the cornea, will be formed first in the superior and inferior quadrants, a statement with which experience stands in perfect harmony.

Every fact hitherto brought forward seems to affirm the nutrition of the cornea as taking origin in the anterior chamber, as is also indicated by the arrangement of the corneal corpuscles. Since they can take up substances only according to their superficies, their position with the surface towards the anterior chamber indicates a current from the chamber. Only in this way are they enabled to make the most profitable use of the nutritive fluid, which sparingly impregnates the substantia propria of the cornea.

If we bear in mind that the described current of fluid in the cornea is physiological, it must change *under pathological conditions*, as soon as one factor, the *anterior epithelium*, is destroyed. The relative impassableness of the epithelium forces the fluid to remain in its proper channels; but, as soon as the substantia propria of the cornea is laid bare, a general current must find its way towards the position in question, and the marginal vessels must necessarily participate in it. Such a condition exerts its influence even upon the anterior chamber, as is indicated by the reduced ocular tension. But, for the present, I must leave it undecided, whether the increased escape of aqueous humor takes place through the cement-lines of the anterior epithelium or from the ligamentum pectinatum. The copious nutritive current, thus brought about, must not only favor the repair of tissue, but I am disposed to attribute to it also the power of producing, if continued longer, an extension of vessels from the adjacent marginal portion towards the defective part.

The dependence of the nutrition of the cornea on the iris explains also the simultaneous appearance of associate diseases in both tissues. Reduced tension in the anterior chamber, so frequent in corneal diseases, must bring about hyperæmia of the iris, and furnish a predisposition for development of iritis. Inflammations of the iris should, *vice versâ*, be associated with diseases of the cornea, but the tolerably tardy metamorphosis in the cornea demands much more persistent and intense disturbances of nutrition (iritis serosa) than occur in simple plastic iritis, because the cornea, by its posterior epithelium, is quite well protected from rapid saturation with pathological substances. Besides, it is worthy of notice that an iritis of any considerable degree does not pursue its course entirely free from change in the cornea. Sometimes the unaided eye, but oftener with the help of focal illumination, succeeds in detecting fine linear and ramifying opacities in every layer of the cornea, evidently corresponding to the structure of the cornea. As, however, immigration from the margin can by no means be excluded, this condition can be made use of only in a qualified sense; at all events, it also illustrates the intimate connection between iris and cornea in pathological changes.

The corneal affections, which come under observation, are largely of a traumatic character (in the largest sense of the word), and iritis is seldom wanting in the so-called parenchymatous forms; opacities of the cornea and reduction of ocular tension suggest the probability of an affection of the posterior epithelium. I incline to the view that precisely in these types the disturbance originates in the uveal tract, as may also be inferred from their binocular occurrence, which is so often noticed in diseases of the uvea, and can be traced back to local or general and constitutional causes (myopia, choroiditis disseminata, retinitis pigmentosa, glaucoma, cataracta senilis, iritis specifica, keratitis parenchymatosa, etc.). It is well known that, if the lens lies against the cornea, particularly for a long time, the corresponding part of the cornea becomes opaque (Arlt, Zehender's Monatsblätter, 1871, page 367).

Since organized elements appear to have no bearing upon the normal nutrition of the cornea—although some white blood-corpuscles are always normally found in the preformed interstices of the cornea—I leave invasion of such elements as an open question, in order not to touch upon a subject about which there still is great diversity of opinion; and still more inflammation of the cornea, which would lead me too far away.

The cornea is nourished from the anterior chamber, the soluble substances passing between the cells of the posterior epithelium into the corneal tissue; the so-called *nutritive canals* serve merely as outlets of the waste fluid.

The posterior epithelium is not a positive obstacle, but merely a regulator of the entrance of nutritive fluid.

The phenomena of nutrition of the cornea are neither rapid nor intense, just as in other cartilaginous tissues.

The corneal margin, for from one to two mm., is not nourished from the anterior chamber, but by the marginal vessels of the cornea; this proposition is derived from certain pathological conditions which otherwise could not be satisfactorily explained (especially the arcus senilis).

The different forms of parenchymatous keratitis can probably be traced to primary affections of the anterior segment of the uveal tract.

IV. *The Corneo-scleral Juncture and the Remaining Channels of the Humors of the Eye.*

Whilst I was enabled heretofore to express myself concisely, since I had already published the essential points of the foregoing chapters (Virchow's Arch., Vol. LXII., page 271, etc., and Vol. LXV., page 401, etc.), I must now treat the following more in detail. The results previously mentioned were obtained by injecting yellow prussiate of potash into the anterior and vitreous chambers; for the present, I have followed the same method, and endeavored, chiefly by injections into the vitreous, to determine the currents of liquids in the eye itself, as well as their outlets from it. The explanation of the results obtained in this manner is neither always easy nor perspicuous. We must always bear in mind that the injected liquid first replaces, on its way, the ocular fluid, and is then in turn continually replaced by freshly secreted fluid. Furthermore, if we consider the greater or less degree of diffusion which takes place between these different fluids, we shall probably have mentioned all the factors that come into play in the experiments, and which must be duly noticed in the interpretation of the results.

Injections into the anterior chamber occasion conditions relatively simple. The whole anterior chamber is filled with the injected fluid, which is gradually displaced by a newly-secreted fluid, and, as we have reason to suppose, is pressed into the natural outlets of dissolved substances. *After some time we find the injected salt only in the cornea.*

At the beginning, a small portion of it is retained in the anterior chamber, but soon disappears, and at the end of three or four hours (in the rabbit) none is found there or in the cornea. *This simple experiment clearly proves that the epithelium of Descemet's membrane does not prevent the passage of dissolved substances from the aqueous humor into the cornea.*

In these experiments, the peripheric portions of the cornea toward the scleral border are intensely tinted, *and the greater part of the liquid injected into the anterior chamber is finally drained off by the subconjunctival connective tissue*, from which location we do not desire to follow it further.

The coloration, according to the quantity of injected fluid and the duration of the experiment, is either limited to the innermost lamellæ of the cornea, or to the whole corneal tissue, as far as the cement-lines of the anterior epithelium, and shows the blue tint in such a manner, that exit through it into the conjunctival sac cannot be altogether denied (with reference to details, consult Virchow's Arch., Vol. LXII., page 271, etc.).

It is evident, on the face of these facts found in the living animal, that experiments on dead animals or on enucleated eyes, however fresh they may be, furnish no conclusive arguments.

It seems strange that Fontana's space itself is hardly ever found tinted, though we must acknowledge that it constitutes an essential drain of the anterior chamber. We shall speak, hereafter, more at length on the explanation of this fact.

The posterior wall of the anterior chamber, particularly the iris and lens, remains in these experiments either totally uncolored or is only so faintly tinted as to lead to the supposition that this slight coloration depends upon a purely physical diffusion, which takes place, not during life, but rather during the interval between the enucleation of the eye and the manifestation of the effects of the chemical reagents. This condition alone is of sufficient evidence to warrant the assumption of the existence of a current of liquid (especially in the lens and anterior chamber) directed from behind forwards, as is demonstrated, beyond a doubt, by injections into the vitreous.

One fact only seems to contradict this supposition, namely, the passage of substances from the surface of the cornea and conjunctival sac into the anterior chamber. In the foregoing chapter, we spoke at length of the experiments pertaining to this fact, and came to the conclusion that the results of these experiments, which led likewise to the supposition of a centrifugal current in the corneal tissue, are quite compatible with the views put forth in this paper. Memorsky found that prussiate of potash, after repeated instillations of strong solutions, could always be detected in the anterior chamber of frogs, but not in that of rabbits. We can readily understand that this is owing to the difference of absolute thickness of the cornea. In man the conditions would be still more unfavorable.

Injections into the vitreous seem to produce more complicated results, yet their explanation is easy, if we bear in mind that the injected liquid must first force out the existing one, and is then itself forced out by liquid freshly secreted. As a first stage, we obtain a condition which I have pronounced constant in one of my previous publications (Virchow's Arch., Vol. LXV., page 401, etc.). We obtain an exit of liquid through Fontana's space, while the cornea does not as yet contain anything of the injected substance.

The locality of this exit, which is not distinguished by any anatomical peculiarity, is not situated exactly in the periphery of Fontana's space, but somewhat nearer to the centre of the cornea. If we consider that, according to physical and anatomical relations, fluid is secreted both from the anterior and posterior surfaces of the iris, it is easy to understand that this colorless liquid must leave the interior of the eye through the periphery of Fontana's space, whereas liquid injected into the centre of the vitreous, and passing from there into the anterior chamber, must be pressed further inwards and exude more centrally, yet still within the area of Fontana's space. As both the injected liquid and that secreted later in the eye have the same outlet, namely, the cement-lines of the epithelium and the lattice-work of Fontana's space, it is not difficult to comprehend that the coloring of a circumscribed region at the corneoscleral junction, and farther back in the sclerotic, fails to prove the existence of a special drainage-channel, perhaps with independent walls, but rather the simultaneous exit of two varieties of fluids by the same passages. We notice here that the mixture takes place only in a very low degree, which is, however, by no means in opposition to the well-known physical phenomena concerning the intermingling of heterogeneous solutions.

The visible blue streak in the sclerotic, depending on the above-mentioned conditions, and having its inner contour better defined than the outer, moves so much nearer Tenon's capsule as it is situated farther back in the sclerotic. I never observed the streak to turn outwards at a right angle (Weiss). In the vicinity of the optic nerve—the locality changes in the various experiments—the blue streak commonly reaches the space of Tenon's capsule, where we will follow it later. The absence of coloration of the innermost layers of the sclerotic is explained by the following facts: a current of fluid takes place, not only from the choroid towards the vitreous, but also—though in a less degree—directly through the lamellæ of the sclerotic. The blue streak of injected fluid, after leaving Fontana's space, is gradually forced towards Tenon's capsule by the liquid exuding in the above-described manner, and which naturally remains uncolored in our experiments. The passage through the dense tissue of the sclerotic must necessarily be more difficult than that through Fontana's space; it must meet with even more resistance than the direct outlet through the cornea, since, according to Sattler's and earlier investigations, several complete endothelial strata from the choroidal capillaries to the sclerotic must be passed; whereas, in the cornea the single layer of cells on Descemet's membrane offers the only obstacle, and the corneal tissue, like that of the sclerotic, is provided with only incomplete and defective layers of endothelium.

The condition, thus briefly described, was the invariable result of my former experiments, which were of short duration; for I imagined the currents of the ocular liquids to be more rapid than they in reality appear; but this condition did not persist throughout their course. When the liquid, injected into the vitreous, after filtration of its greater part through the zonula Zinnii, and the passage of its smaller part through the interstitial substance of the fibres of the lens, finds its way into the anterior chamber, and penetrates also the cornea, after having gradually forced out the aqueous humor. At this period, no essential differences remain between the conditions resulting from injections made directly into the anterior chamber and such made into the vitreous; and these differences are easily explained if we consider that the parenchymatous fluid, secreted by the uveal tract, shows a natural tendency to displace the injected fluid towards the centre of the eye. Since, in the former case, a colorless parenchymatous fluid instantly flows into the anterior chamber, the injected solution of salt must be forced more towards the centre of the cornea than if a continuous current existed for a longer period of time from the vitreous into the anterior chamber. Since the fluid, coming from the interior of the eye, tends by preference towards the place of easiest discharge, *i. e.*, Fontana's space, it is readily understood why prussiate of potash, if injected into the vitreous, makes its appearance in more peripheric portions of the cornea, resp. the corneo-scleral margin, than if injected into the anterior chamber, provided the examination is not made too early. In reference to this stage, I have not as yet made any experiments. Examinations made at a later stage may prove successful, as in the instance of the right eye of a cat upon which I operated March 26th, this year. In this case the innermost lamellæ of the cornea were again colorless, as well as those portions of the corneo-scleral margin corresponding to Fontana's space; the blue color spread in the region of the former towards the subconjunctival tissue, but the last traces of the above-mentioned blue streak were observed farther back in the sclerotic; that portion of the sclerotic situated exterior to the blue streak showed a somewhat paler blue color; coloring matter was also found in Tenon's capsule and on the inner surface of the straight muscles of the eye. This picture corresponds to the condition in which the continuous secretion commences definitively to displace the solution of ferrocyanide of potassium injected into the vitreous.

We have already mentioned *that the greater part of the injected fluid which penetrates the cornea finds its outlet in the direction of the subconjunctival tissue.* If we examine parts of this tissue, we find, in the majority of cases, only a diffuse coloration; sometimes we succeed, as I have already mentioned in my first paper on injections into the anterior chamber, in demonstrating colorless stellate connective-tissue corpuscles in a blue basis-substance, provided the examination be made early enough. We must assume here, as well as elsewhere, that the fluid really escapes into the spaces of the connective tissue towards the larger lymph-channels; that during this passage a mutual reaction takes place between the prussiate of potash, lodged in the interfascicular spaces, the capillary lymphatics, and the adjacent tissue, which is partially saturated with the coloring fluid, whilst the living connective-tissue corpuscles, on the other hand, do not absorb salt. This explains conditions found later in the orbit, namely, that the blue coloration is always found more or less diffuse, never entirely restricted to the capillary interfascicular spaces, which surely represent the true drainage channels. In this manner we must also interpret the blue streak which corresponds to the first exuded portion of prussiate of potash injected into the vitreous.

Discharge from the corneo-scleral margin, and especially from Fontana's space, takes place, not only in the direction of the subconjunctival tissue, but directly towards Tenon's capsule. We have already mentioned that the blue streak formed by the prussiate of potash injected into the vitreous is so much more apt to approach the "articular capsule of the eye," and finally empty into it, the farther back it is situated in the sclera. But we find, at a somewhat later stage, the dark coloration of the corneo-scleral margin, extending not only towards the subconjunctival tissue, but directly towards Tenon's capsule. At this period the often-mentioned blue streak seems no longer to exist; it is forced out of the sclera by the newly secreted parenchymatous fluid. *Coloration of the most anterior segments of the peripheral scleral lamellæ is observed in connection with the coloration of the corneo-scleral juncture, and this coloration changes constantly into a bluish tinge throughout the orbital tissues.*

The cavity of Tenon's capsule contains no more salt solution than any other connective-tissue space from which it is only distinguished by not being bordered, like the other free spaces in the areolar tissue, by irregularly interwoven layers of connective-tissue bundles, but by parallel layers of the adjacent tissue. The orbital tissue included within the "muscle-funnel" then shows for the unaided eye a diffuse coloration which, according to the relative duration of the experiment, extends more or less towards the apex of the orbit. Here we distinctly see that the darkest coloration corresponds to the inner surface of the straight muscles and to the loose connective tissue in which the retractor bulbi is imbedded; that the space between the outer and inner nerve-sheaths contains a proportionately greater mass of prussiate of potash. By making successive horizontal sections through the orbit, commencing at the posterior portion and cutting outwards, we notice that the prussiate of potash has extended farther back into the loose connective tissue surrounding the muscles, and into the space between the optic-nerve sheaths, than in the remainder of the orbital tissue. The optic nerve itself contains nothing. Microscopical examination demonstrated a diffuse coloration of the connective tissue in the orbital cavity. I am fully convinced that the main current of fluid, here as well as in the subconjunctival connective tissue, runs in the lacunæ of the areolar tissue; that the coloration of the basis-substance of the connective tissue depends upon the mutual reaction between the salt-solution and the surrounding tissue, and that our failure in not bringing to view the connective-tissue corpuscles uncolored must be attributed to the death of the latter before the formation of a precipitate of the ferrocyanide of potassium by means of chloride of iron, and to their imbibition and quasi coloration with prussiate of potash. Either the action of the reagents in a whole orbit is too slow, or the failure depended upon my being unable to make the microscopical examination early enough; the former reason appears to me the more probable. In accordance with the previous statements is the fact that *the darkest blue coloration within the orbital tissue was to be met with about the larger vessels*, and we are not likely to be mistaken if we ascribe this fact to the circumstance, that the perivascular lymph-spaces, as tne last means of discharge, contain a large quantity of prussiate of potash. One of my preparations (Dog; injections made into the vitreous, April 12th, 1878; animal killed six hours afterwards) showed a dark blue coloration about the vessels (art. ophthalmica and its branches), as far as the apex of the orbit, whilst the blue coloration in the orbital connective tissue had penetrated only a short distance into the depth of the orbit, though somewhat more in the optic-nerve sheath and the loose connective tissue about the muscle. The vessels with arterial character had a *very well defined adventitia which alone was colored.* Up to the present time I have been unable to trace the fluid injected into the eye any farther.

I have still to describe an unusual condition, which I observed in the left eye of a cat, operated upon March 26th, 1878. Five minutes after nine A.M., a solution of ferrocyanide of potassium was injected into the vitreous during one minute and a half and with considerable force, whereby the pupil became widely dilated and remained in this condition for almost an hour; the animal was strangled five and a half hours later. In this case the blue streak could be traced as far as the entrance of the optic nerve, without having previously emptied into Tenon's cavity; the optic papilla showed an intense blue coloration, as did also the subvaginal space, but only in the immediate vicinity of the sclerotic.

The blue coloration of the optic papilla was in direct connection with that of the subvaginal space, but was separated from the vitreous chamber, which still contained a considerable amount of ferrocyanide of potassium, by a zone of uncolored tissue of about the thickness of the retina. The fluid. injected under great pressure, had, no doubt, strongly compressed the chorio-capillaris, thus retarding and diminishing its secretion, and causing the blue streak of the prussiate of potash, exuded through Fontana's space, to remain in the sclerotic as far as the optic-nerve entrance. The optic papilla must possess a very peculiar system of lymphatics, as is also indicated by some phenomena of the so-called choked disc, and to which attention has already been directed by other writers. I was unable to observe any details in my preparation, and as I obtained the described condition but once, I am compelled to restrict myself entirely to these statements. No trace of the injection was to be seen in that part of the optic nerve situated beyond the sclerotic. A sufficient explanation of this may, perhaps, be found hereafter. I wish still to mention that I have often perceived, during my injections both into the vitreous and into the anterior chamber, a larger or smaller blue coagulum, though I carefully cleansed the conjunctival sac immediately after every injection. This occurrence shows that intraocular fluid may also pass in small quantities through the cornea or subconjunctival tissue into the conjunctival sac, as we might have expected in comparing the true anatomical conditions with the results obtained by our experiments, for there is no reason to preclude the diffusion of prussiate of potash into the conjunctival sac, when found in the cement structure of the anterior part of the cornea or in the epithelium of the conjunctiva.

I have hitherto only occasionally cited individual experiments, and do not intend, for various reasons, either to communicate all my experiments, or even the greater part of them, *in extenso*. As they extend over a period of about four years, it would occupy an inordinate amount of space, without saving any one who wishes to test the opinions advanced, the trouble of repeating the experiments. Exactly those experiments which seemingly failed, yielded often suggestions, especially as to the method which must first be tried in every single species of animal used for experimental purposes. Therefore, it is no more than proper that I make a few remarks upon the method and means which I employed. In rabbits, as already mentioned, hardly any orbital tissue is to be found, and all endeavors to demonstrate effluent passages failed; on the other hand, rabbits are well adapted, on account of the thin walls of their eyes, to demonstrate the conditions of the intraocular currents. As my communications on this subject would contain scarcely anything new, I can only refer to my earlier publications in Virchow's Archiv. From the opposite reason, all efforts to prove intraocular or extrabulbar passages failed in the horse, cow, and goat. The absolute size of the eye and orbit produced appearances of putrefraction, since the reagents could not act promptly enough. Generally, all efforts towards the detection of Prussian blue, in these cases, were attended with failure, and in this manner, for instance, two Pravaz's syringefuls of a solution of ferrocyanide of potassium, injected into the eye of a cat, without any undue force, disappeared entirely. At times, a blue coloration, although only diffuse, oftener punctate, could be produced by subsequently treating sections of eyes with acids and ferrum chloride; such preparations, of course, were useless.

The first reliable results were obtained after restricting my experiments to cats and dogs. In these animals it is easy to demonstrate drainage canals in the cornea, sclera, and farther back in the orbit, although certain means of precaution are to be observed even here. The experiments must be instituted in the simplest manner, and a very small quantity should be injected with the slightest elevation of pressure. I think to have satisfied these three requisites by the following method which I finally employed in preference to all others.

The animal was properly secured and the lids held apart by an assistant; the remainder can be achieved unaided. Seizing with the fixation forceps a tendon—commonly that of the superior rectus, since the conjunctiva, grasped alone, often tears, nor does it sufficiently fix the globe—I made the injection into the vitreous at some distance from the fixing point and as far back as possible, without touching the opposite wall of the eye. Notwithstanding the seeming simplicity of this procedure, a certain degree of practice is required.

For injecting I employed a small caoutchouc balloon, into the mouth of which I inserted a water and air tight, and, as far as possible, immovable canula of Pravaz's syringe. The balloon for the greater part was filled with air and clasped by the whole hand, which exercised the necessary pressure. This pressure, in consequence of the resistance offered by the air, is, of course, elastic, and can be regulated by noting the behavior of the pupil. If the latter dilates widely, we must interrupt the experiment, but the necessary quantity of fluid can be injected into the eye with the greatest facility during an interval of one-half to two minutes, without materially increasing the ocular pressure, if a certain degree of prudence is observed. All complicated apparatus proved either useless or inadequate, and the uniformity of results necessary to admit of certain conclusions regarding the changes in the living eye was obtained only by the most simple manner and means. I have employed this method ever since the summer of 1877, and am exceedingly well pleased with it; in fact, so much so that I would recommend it to any one who desires to perform similar experiments.

An embarrassing condition, to which I must certainly call attention, depended on our inability to institute a complete series of experiments; these would have been of great importance in the present state of affairs. The difficuly of obtaining animals for experimental purposes obliged me to take the animals as they were offered. Since also the age of the animals, which could only approximately be determined, must exert a great influence on the rapidity of the fluid-currents, I can in this respect draw conclusions from my experiments only with great caution. The following statement may suffice: six to eight hours are required in the dog and cat for the passage of fluid from the vitreous chamber into the orbital tissue; but it also happens very often that the sclero-corneal margin commences to stain only after the lapse of six hours. It seems very probable, judging from my experiments, that the transport of fluid occurs far more rapidly without than within the eye, as seems to be confirmed by clinical experience also.

I have hardly mentioned the results obtained by others from injecting solid substances into the tissues and cavities of the eye. They have less in common with the fluid-currents here described than would *a priori* be supposed. In the first place, the migration of solids in the normal eye, in particular of red and white blood-corpuscles, granular pigment, etc., is very limited; secondly, we can readily conceive that a fluid can still pass where a solid, provided it remains undissolved, cannot.

These bodies, wheresoever found in the normal eye, are lodged in the preformed spaces of the tissues; nowhere are we able with certainty to ascertain their passing through closed structureless membranes, which offer no hindrance whatever for dissolved substances, as was shown by our experiments. The results which, while examining choroidal tumors, I obtained in regard to the displacement of the pigment of the destroyed choroidal elements, harmonized very well with the above-mentioned facts. That part of these investigations which had reference to the pathological anatomy of choroidal sarcoma was published in these ARCHIVES, Vol. VI., page 376, etc. These results admit of a more detailed discussion only when compared with a sufficient number of experiments made on the healthy eye. Injections of formed particles into the eye have thus far proved so injurious that panophthalmitis and even the death of the animal have been caused by them. They, therefore, do not admit of conclusions being drawn from them as to normal conditions. I scarcely ever came across a case in my various injections into the cornea and vitreous body that showed more inflammation than, perhaps, some coagulation of the aqueous; neither have I as yet observed a case of panophthalmitis, although often allowing the animals to live, in order to observe what effect the injections had on the eye. It is reserved to future experiments, appropriately modified, to determine the avenues also for solid particles in the eye.

I have not mentioned a question which of late has again been brought up for discussion (Stilling), namely, whether drainage passages of the intraocular fluid are also to be sought for in the optic nerve. No satisfactory observations have been brought to bear on this question, and from my experiments I can only conclude that, if effluent passages really do exist, they must, under normal conditions, be of little importance. A discharge through the optic-nerve sheaths does exist, though the sheaths communicate only with the suprachoroidal space, not with the vitreous body. My experiments point also to a probable communication between the optic-nerve sheaths and the cavity of Tenon's capsule. The avenue of discharge through the optic nerve may perhaps gain a somewhat greater importance under pathological conditions; this, at least, did not seem improbable to me on examining preparations of glaucomatous excavations in choroidal sarcomas. At all events, the conclusions derived from these experiments show that the solution of the question by tying the optic nerve is not altogether beyond criticism, and that the results thereby obtained admit also of another interpretation.

If, in conclusion, we briefly sum up the results obtained from the before-mentioned experiments, we would conceive the currents of fluid in the living normal eye to be about as follows:

Disregarding for the present the vascular province of the retina, the looped network on the border of the cornea, and the scanty vessels of the sclera, we must consider the chorio-capillaris of the uveal tract as the essential locality of the secretion of the intraocular fluids. Fluid exudes here, not only outwards towards the suprachoroidal space, but also inwards through the retina into the vitreous; evidently the far greater mass of fluid passes through the latter passage. The fluid which exudes directly outwards must reach the suprachoroidal space, and from there is in part conducted through the subvaginal space of the optic nerve. A portion will slowly filtrate through the sclera as it does from the anterior chamber through the cornea. We must bear in mind that the scleral interfascicular spaces communicate also with the sheath of the optic nerve, and that a current of fluid must be present in the sclera, which passes in the direction of the scleral interfascicular spaces toward the optic nerve. Another portion will pass along the connective tissue, about the perforating vessels and nerves, directly permeating the sclera, and empty into the cavity of Tenon's capsule, to which, to be sure, our experiments point but indirectly or *per analogiam*, but which I may affirm from observing certain pathological conditions connected with the growth and extension of choroidal sarcomata.

That portion of the fluid secreted by the chorio-capillaris, and which is here of most interest, passes through the retina into the vitreous by channels which seem to be indicated by the structural conditions of the retina (Müller's supporting fibres). Since secretion takes place simultaneously from all the parts of the choroid, which exceed a hemisphere in size, the fluid which flows through the vitreous in an anterior direction must be crowded, so to speak, toward the lens. Whilst the smaller part of this fluid flows through lens-capsule and interfibrillar substance in the direction of the anterior chamber, the greater part of it passes directly through the zonula Zinnii into the posterior and anterior chambers.

Here we must consider the anterior and posterior surfaces of the iris—the latter, according to the anatomical position of the capillaries, probably of greater importance—as secretory organs, and the fluid secreted by the iris, together with that formerly contained in the vitreous and lens, forms the aqueous humor.

The aqueous finds an outlet in the following manner: it passes between the endothelial cells of Descemet's membrane into the cornea, and from there slowly outwards in the direction of the corneal interlammellar spaces towards the scleral border, and especially towards the loose subconjunctival connective tissue. But we must also assume that a dribblet of intraocular fluid can reach the conjunctival sac by passing between and through the corneal and conjunctival epithelium.

The greater part of the aqueous humor leaves the eye in the region of the so-called Fontana's space, which, by its anatomical peculiarity, affords the most favorable conditions of drainage. The dividing fibres of Descemet's membrane open the interfascicular spaces of the cornea and sclera into the anterior chamber, as is shown by the observation of anatomical prepations of this region. Here the innermost corneal lamellæ take an outward turn, and the interlacing of the tissue of the corneal margin at Schlemm's canal, which is surrounded by a small quantity of a loose connective tissue extending, along the perforating vessels, directly outwards, facilitates the direct passage of fluid into Tenon's capsule and the subconjunctival tissue.

But a part of the liquid, escaping through Fontana's space, follows the course of the essentially concentric interfascicular spaces in the sclerotic, successively passing from the inner to the outer layers, until at last it reaches the space of Tenon's capsule and the sheath of the optic nerve. In these parts the liquid is absorbed, as by a sponge, by the fibrous portion of the orbital tissue within the muscle-funnel, chiefly by the loose connective tissue surrounding the muscles, no doubt on account of the perforation of Tenon's capsule by the tendons of the muscles. Finally we can detect the intraocular liquid in the course of the lymphatics and the lymph-sheaths of the larger arteries.

I will here mention that the orbital connective tissue seems to a certain degree to play the part of lymphatic glands. Frontal sections through the orbit show here and there in the course of the fibrous tracts a tissue bearing the greatest resemblance to the structure of lymphatic glands, with this difference, that the interstices of this adenoid or reticulated connective tissue are not so densely crowded with white blood-corpuscles as we find it in true lymphatic glands.

The chief fluid-current is hardly changed by the subordinate vascular provinces in the eye. The scleral vessels are of little account. The quantity of liquid escaping from the retinal vessels evidently increases only the current proceeding from the chorio-capillaris toward the vitreous body, and the action of the net of loops at the corneal margin, as we have above stated in detail, seems to be limited exclusively to the peripheral parts of the cornea.

I still wish briefly to draw the attention of the reader to one fact. The chief current evidently advances in the interfascicular spaces of the fibrous tissue; and the coloration of the basis-substance indicates only the mutual reaction between the substances in the interfascicular spaces and surrounding tissue. This tendency to follow the interfascicular spaces is best illustrated by the blue stripe in the sclerotic which appears at a certain time; but we must assume that it is present in the cornea and the connective-tissue tracts of the orbit, as well as in the sclerotic, the tissue of the cornea and the sclerotic forming not merely concentric layers, but an irregular latticework. This supposition is in perfect accordance with the results of our experiments, as in the cornea, for instance, the injected liquid only gradually reaches the anterior parts.

The great permeability of the tissue surrounding Fontana's cavities and of the retina are, as we have stated, easily explained by the structure of the connective tissue. Considering that the main current passes through the interfascicular spaces of the connective tissue, we can readily account for the effect of iridectomy in glaucoma, since in the region of the section a tolerably direct communication between the anterior chamber and the subconjunctival tissue is established, and we have seen that the subconjunctival connective tissue constitutes one of the most important extrabulbar drainage passages of the intraocular liquid. In conclusion, I venture to assert that the views advanced in this paper, concerning the fluid-currents in the eye, which are the results of numerous experiments made during several years, and which already seem to throw new light on some obscure subjects, are in perfect harmony with the general principles of physics, anatomy, and physiology, and, moreover, are supported by their harmony with clinical experience. I have endeavored to abstain from entering too deeply into details, leaving it to the judgment of the reader to submit the results of these investigations to the test of clinical facts.

TWO CASES OF PENETRATING WOUND OF THE SCLEROTIC CURED BY CATGUT SUTURE.

(From the Clinic of Prof. Jaeger, Vienna.)

By Dr. CHARLES KERZENDORFER.

Translated by Edw. Fridenberg, M.D.

Though even extended penetrating wounds of the sclerotic may, by proper treatment, be cured, without either form or function of the eye being lost, as a rule, we cannot expect a successful result even after the best and most careful treatment. *A priori*, the conditions for healing "per primam intentionem" are wanting. The reaction of the tissues causes the wound, especially when large, to gape, and the vitreous, by its constant outward pressure, prevents the apposition of the lips of the wound, besides inducing pernicious suppuration, or, later on, atrophy. To treat a scleral wound correctly, we must, therefore, provide the conditions requisite for union by the first intention. An accurately placed suture is the essential thing; the edges of the wound must first be carefully prepared, and all tissues which have prolapsed or lost their vitality through the violence of the injury must be removed.

Silk, the material in use thus far, cannot be recommended for sutures in the sclerotic. For the threads have to pass through the entire thickness of the tunics of the eyeball in order to prevent even a partial prolapse of the vitreous, and remaining for a considerable interval of time, they are apt to irritate and to cause inflammation. If removed before union is complete, the edges of the wound often separate, recovery being thus greatly retarded.

In December, 1876, the frequent occurrence of panophthalmitis, apparently caused by prolonged retention of the sutures after Critchett's staphyloma operation, led me to try Lister's carbolized catgut instead of the silk ordinarily employed. If the tissues of the eye should tolerate catgut as well as most tissues of the body (and why should they not?), the sutures would be retained until perfect consolidation had taken place, without fear of suppuration. A series of staphylomas, containing also cases for which Critchett's method is not usually recommended, such as intercalary sclerectasias, etc., were operated in this manner, with excellent results, thus demonstrating practically the correctness of my *a priori* theoretical considerations. Reaction was nil. The threads left in place were either entirely absorbed, or showed as delicate white lines. As the knot is apt to slip, thus endangering the result of the operation, it is important that it be tied carefully.

After such good results with the catgut suture, I resolved to use it in penetrating wounds of the sclerotic; and now I have two cases of the kind to report.

Josephine M——l, aged 14, was admitted to Prof. Jaeger's clinic on August 19th, 1877. A quarter of an hour before admission, the left eye had been struck by a piece of broken glass.

On the upper lid a few small excoriations. The eyeball is the seat of a widely gaping, penetrating wound, with smooth walls and angular ends, commencing at the corneal margin in the vertical meridian, and running inwards and backwards for about one centimetre and a quarter. Prolapse of iris and of vitreous. Considerable hemorrhage. Condition of lens not to be determined, owing to the effusion of blood. Quantitative perception of light. Patient was sent to bed and applications of ice were ordered.

August 20th.—Patient being profoundly anæsthetized, I snipped off the torn portions of iris and the prolapse of the vitreous, and closed the wound with three catgut sutures. These were passed, not through the sclerotic alone, but through the entire thickness of the tunics, thus, of course, piercing the ciliary body also. There was but little hemorrhage. Conjunctival wound not interfered with. Ice.

August 21st.—No pain. Anterior chamber restored and half full of blood. Pupil dilated by atropine. No injection except in immediate neighborhood of wound.

August 25th.—Wound projects. Applied compress bandage. The conjunctival wound has healed completely, the lowest suture only is visible.

August 26th.—Ophthalmoscopic examination. Lens in place; a small central opacity in the posterior cortical substance; some floating opacities in the vitreous. Fundus not visible. Fingers were counted at $\frac{1}{2}'$.

August 28th.—Nearly all the blood is absorbed from the anterior chamber. The ophthalmoscope does not detect any changes corresponding to the external wound. Some retinal vessels visible.

September 1st. Vitreous is clearing up gradually. Opacity of lens has not increased. S.$=\frac{20}{100}$. From this time the appearance of the eye improved steadily. On the 19th of September, the patient was dismissed, having been kept in the institution in order that that the eyes should not be used too soon. The scar was perfectly smooth, only noticeable by its pale-blue color. The narrow coloboma of the iris is completely concealed by the upper lid. Pupil reacts promptly. In the vitreous two to three floating opacities. Three months later patient had S.$=\frac{20}{70}$ and read Jaeger No. 4.

Franz Chm——k, aged 20, a wheelwright, was admitted to Jaeger's clinic on September 18th, 1877. In the forenoon of the day of admission, the left eye was injured by a link breaking from a stretched wagon chain. After arranging his household affairs, he applied for admission in the evening. The upper lid hung down, as if the orbit were empty. A viscid sanguineous fluid flowed from the palpebral fissure over the cheek. The eyeball lay deep in the orbit, like a soft bag. In the outer and lower segment, commencing about one millimetre to the inner side of the corneal margin, there was a penetrating wound, about one centimetre long, with irregular and gaping edges, from which bleeding choroid and vitreous protruded. Cornea turbid, but through it the iris was seen to be slightly torn at its pupillary margin. The lens had probably been driven out by the violence of the injury. Preception of light wanting.

Although an unfavorable result seemed most probable, I resolved to try the catgut suture. The patient being under the influence of an anæsthetic, the prolapsed internal tunics of the globe were carefully removed, the lips of the wound trimmed, and three sutures applied;

the first at the sclero-corneal junction, the thread being concealed in the tissues ; the second at a distance of about five millimetres, passing through the whole thickness of the walls, and the third beneath the conjunctiva. Considerable hemorrhage during the operation. Applications of ice.

September 19th.—Globe very small; little pain.

September 20th.—Considerable chemosis ; greater part of cornea covered by the swollen conjunctiva. After local blood-letting and continued application of ice, the pain and swelling had almost disappeared toward evening.

September 23d.—Turbidity of cornea less ; little blood in anterior chamber. Defect of iris downwards and outwards. Eyeball pretty full, but very soft. Ophthalmoscopic examination shows considerable intraocular extravasation. Strong light thrown into the eye with a mirror is readily perceived, the external portions alone being insensible. Sutures not visible.

September 25th.—Extravasation diminishing ; a whitish reflex upwards and outwards, as seen in detachment of the retina.

September 28th.—On examination in the inverted image, a retinal vessel is visible occasionally. Eyeball well filled. No sensation of pain. For two days, protective bandage. After repeated changes in the injection of the conjunctiva, and of the episcleral tissue, with varied sensitiveness to light, the eye became quiet three weeks before the discharge of the patient on December 31st, 1877.

At this time the eyeball was nearly as full as the right eyeball, the tension somewhat less. No perceptible scar. Pupil black, behind it oblique illumination showed a transparent folded membrane leading to the wound. Few opacities of vitreous. Disc and ramifications of retinal vessels plainly visible. Patient recognized motions of the hands at a distance $1\frac{1}{2}'$. The visual field showed a defect corresponding to external portions.

In applying the suture, the only difficulty met with is the great delicacy of manipulation which is needed. The edges of the wound being very mobile and offering little resistance to the needle, they must be fixed by a forceps or a sharp hook.

The sharp hook is undoubtedly the better instrument, as in using the forceps it is not easy to avoid bruising the parts.

I know that in the above paper I have not offered anything new in principle. I have published the above facts in order to draw attention to the catgut suture, which, strange to say, has not yet been introduced into ophthalmic surgery. I believe that its use will frequently be followed by commendable results, while it can hardly be productive of harm.

ON THE PATHOLOGY OF THE SYMPATHETIC NERVE.

By Dr. M. LANDESBERG, of Philadelphia.

Amaurosis or amblyopia without demonstrable ophthalmoscopic changes, so-called "*amaurosis or amblyopia without ophthalmoscopic evidence*," is no longer counted among the rare and exceptional appearances which are observed in oculistic practice. The nature of the phenomenon, however, the connection between cause and effect, has not yet been detected. In a number of cases we observe a total loss or considerable impairment of vision, without being able to ascertain any material lesion of the eye, any anatomical alteration of its tissues, as the cause of this morbid disturbance. After thirteen years of progress in our special branch of science, the following remarks of von Graefe have lost nothing of their validity:* "I have observed all forms of amblyopia or amaurosis in absolutely healthy people, respectively under so uncertain general symptoms, that I must confess, in most cases, my utter ignorance of the cause of the affection. If observed after blood-vomiting, consequent upon gastric disorders in acute exanthemata, the connection between cause and effect cannot be explained at the present state of our knowledge. In this difficulty, some authors have resorted to the common sheet-anchor, the vaso-motor influences, respectively the spasm of the vessels brought about by disturbances of the vaso-motor innervation—a supposition supported sometimes by various symptoms of the retina and the general condition of the patients. But when will we succeed in fertilizing this inviting soil with the seed of real facts?"

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* See: Vorträge aus der Von Graefe'schen Klinik, published by Dr. Engelhard. Monatsblätter für Augenheilkunde, Mai und Juni Heft, 1865.

We have, for the present, to content ourselves with the consolatory argument, uttered by Griesinger under similar conditions in his special branch of science: "The anatomical conception does not consist in asserting that every disturbance of the mind is caused by a demonstrable alteration of the brain; the anatomical conception demands only the investigation of the conditions usually found in post-mortem examinations of the insane, and then, by comparing these conditions and the phenomena observed, arrive at broader anatomical views as to the affections of the brain."

If we observe that in a great number of cases of blindness, there are no demonstrable ophthalmoscopic changes in the eye, the study of intraocular diseases discloses to us another point which is worthy of the greatest attention. I refer to the utter impossibility of estimating the loss of vision from the demonstrable morbid ophthalmoscopic changes only; the disproportion which exists between the results obtained by functional examination and the ophthalmoscope. How often would we incline, if not guided by functional examination, and judging from the ophthalmoscopic evidences alone, to consider just that eye to be seriously affected which is either absolutely normal, or the affection of which is very slight, while the other eye appears to us quite normal, but its sight is either greatly endangered or already totally lost. And what is more, in many cases of intraocular affection with considerable impairment of vision, and marked alterations of the background of the eye, we succeed in checking the morbid process, improving vision or restoring it to its former power, while the background of the eye remains unchanged. Thus the finer processes in the life of the organs are completely beyond our present means of investigation. I was induced to make these introductory remarks by the study of a case which, owing to the peculiarity of its symptoms, is of great importance.

A. K., engineer, 23 years old, applied to me June 17th, 1873, complaining of temporary loss of vision in the left eye. The first attack of blindness occurred in March of the same year, lasted for several hours, and was followed by complete recovery. Such attacks of transitory monocular blindness were repeated four times, while in the intervals the eyes, as well as the general condition, were perfectly normal.

The anamnesis was as follows: Patient, born of healthy parents, the youngest of four healthy children, was always strong and well, free from any serious illness. There was no nervous diathesis, no tendency to headaches. Mental overstraining was admitted, but not lately, especially not at the period of the first attack of blindness.

Concerning the first outbreak and the course of blindness, the statements were as follows:

On the morning of the 9th of March, after applying himself for a few hours to mathematical studies, which did not require unusual mental efforts, patient suddenly felt as if the letters of the book ran together, dancing before his eyes, while the lines seemed to stretch, distend, and revolve in concentric circles. When he looked up from the book, the room appeared to be filled with fog, in which large, round dark spots were continually moving up and down. He experienced, besides, violent pulsation in his temples, impairment of vision, inexpressible anxiety, and the feeling of heat mounting to face and head. He obtained some relief by closing his eyes, especially by pressing them gently with the palm of his hand. How long this paroxysm lasted, patient was unable to state. He must have lost his consciousness for some time. When he recovered his senses, he felt sharp cutting pain in his left temple; the fog was less dense, and the oscillations of the dark spots less violent. The latter grew paler and gradually vanished. The feeling of anxiety subsided. The objects in the room, which in the beginning of the paroxysm seemed to whirl around, became steady. In this state patient discovered *that he had lost the sight of his left eye.* By what chance he was brought to make this discovery, we cannot say. The whole field of vision appeared to him "gray in gray." This monotony was interrupted by slight flashes and sparks, arising and vanishing abruptly, and being perceived when either or both eyes were closed.

Patient not being able immediately to send for a physician, ordered the room to be darkened, went to bed and took some hot tea, whereupon profuse perspiration set in, followed by sound sleep.

When he awoke, about midday, he felt greatly relieved. The cutting pain and the pulsation in the temples had diminished. The head was freer. The sparks and flashes of light were gone. But there was no change in the condition of his left eye. In the course of the afternoon, when the general improvement was steadily progressing, vision also gradually reappeared, so that in the evening the eye could distinguish every object in the room. The following morning, the vision of both eyes was totally restored, but every attempt at reading or fixation was followed by a sense of pressure in the left temple and scintillation before both eyes. On the third day after the attack, there was complete recovery.

After two weeks of perfect health, patient had a second attack, which followed the same course as the first. The blindness of the left eye set in after the paroxysm had become localized in the left half of the head; it lasted several hours, and subsided with the improvement of the general condition. On the following day there was perfect recovery.

Up to the 13th of June, the attacks were repeated three times. The effects of the last paroxysm were of longer duration and greater intensity than the preceding ones. Photophobia was still present on the fourth day of the attack, and binocular fixation was greatly impaired.

Patient, of slender build, but strong constitution, is slightly anæmic. His face is pale, expressing great suffering. General condition otherwise normal. The examination of both eyes showed :

V.$=\frac{15}{15}$. Jaeger 1 from 3″–15″, F. normal. Equilibrium of the associated muscles intact. Both pupils react equally well consensually and on reflex action. Perception of colors, background of eyes, and intraocular pressure normal.

I refrained from making any diagnosis, asking the patient to give me an opportunity to learn by personal observation the true nature of his affection.

He did not comply with my request for four weeks, during which time bromide of potassium, taken by advice of another physician, had not prevented two further attacks.

Examination, repeated on the 25th of July, gave the same results as noted above.

On the morning of August 6th, about 10 o'clock, I was called to see A. K., when the paroxysm had just begun. Half an hour later, I found him in the following condition :

He was lying in bed, in a dark room, covering the eyes with his hands. The face was flushed and wet with perspiration. The palms were moist. Radial pulse full, strong, about 90 in the minute. Consciousness perfect ; voice feeble, distinct. Respiration and action of the heart increased. Sounds of the heart normal. He complained of violent palpitation of the heart, which, however, was not ascertained by objective examination. Great anxiety and uneasiness. There was very great cutaneous hyperæsthesia and hyperalgesia of the left half of the head, radiating also to the right half. The left temporal region was distinguished by the strong visible pulsation of the temporal artery, which, highly tortuous and dilated, rose above the level of the skin, with a full and hard pulse. The artery in the right temporal region was also larger and more tortuous than in the normal condition. Patient complained of very severe cutting pain in his left temple, which somewhat subsided by pressure on the temporal artery. But this pressure was only borne for a short time, and was followed by more violent pain. There was a sore feeling in the right part of the head.

The condition of the eyes was as follows :

Right Eye.—Position, tension, and mobility normal. Conjunctiva slightly injected. Cornea clear. Iris dark-brown, of normal tissue. Pupil showed a slight degree of myosis; contracted under influence of light to the size of a pin-head, the following dilatation was but slow. It was impossible to determine with any exactness the sight and field of vision. We must rely upon the statements of the patient that his vision was not affected. The second-marks on the dial of a watch were correctly distinguished. Fixation was difficult, and the slightest exertion gave rise to nausea.

Left Eye.—Movements normal. Slight exophthalmus. Hyperæmia of palpebral and ocular conjunctivæ. Cornea clear, of normal curvature and sensibility. Iris dark-brown, of normal tissue. *Pupil was at least twice as large as the right one, and its dilatation, compared with previous observations, was positively pathological. Intraocular pressure increased. Vision entirely lost*, patient not being able to distinguish the fingers of my hand close to his face, but perception of light in all parts of the field of vision was preserved, the projection was correct, and even binocular fixation seemed to be present. Reaction of pupil on light was consensually not quite lost, but could only be perceived by close attention. Several sectors did not contract. The reflex reaction of the pupil was prompter ; though likewise absent in several sectors.

I was obliged to refrain for the moment from an ophthalmoscopic examination of the left eye, patient not being able to bear the light. I could only make a very superficial examination of the right eye, after bandaging the left, and making the light very small. The background was absolutely normal.

The subjective phenomena of sight, sparks, flashes, and dark spots moving in the gray fog, were present as above described.

The attack set in under the above-mentioned symptoms. When I saw the patient, two and a half hours later, his general condition was but very little improved. Left-sided headache persisted in full violence. Face highly flushed. Cutaneous hyperæsthesia and hyperalgesia somewhat abated, myosis of the right eye diminished. The condition of the left eye was unchanged. The examination of the background of the left eye with the plain mirror of Schweigger's ophthalmoscope *did not show any deviation from the normal condition. The ophthalmoscopic appearances of both eyes were the same.*

The attack was this time more violent and longer than the preceding ones. In the evening, I found the patient improving. Left-sided headache considerably reduced. Pulsation of the temporal artery weaker; the artery itself not so hard to the touch and less tortuous. The photopsia had disappeared. No trace of hyperæsthesia and hyperalgesia. Lids spontaneously open. Face somewhat pale; left conjunctiva slightly injected. Left eyeball no longer protruding. Respiration, temperature, and radial pulse normal.

Right Eye.—Normal pupil, with normal reaction on light.

Left Eye.—Intraocular pressure still somewhat pathologically increased, but much less than during the day. Left pupil larger than the right, in all its sectors promptly reacting on light, but still more slowly than the right. Patient counted fingers at 10′, his field of vision normal.

Background of either eye unchanged. I ordered a dose of 3 grm. of hydrate of chloral for the night.

Patient slept very well during the night. In the morning, I found him still greatly exhausted. Face very pale. Radial pulse weak, slow. Left temporal artery slightly tortuous, its pulse small, jumping. No trace of headache, hyperæsthesia, or hyperalgesia. He complained of being unable to collect his thoughts, his head being dull and confused.

Both pupils were equally large and responsive to light. Intraocular pressure of both eyes normal. There still was slight scleral injection of the left eye.

Patient read with the right eye Jaeger 1 from $3\frac{1}{2}''$–$15''$, with the left eye, Jaeger 3 fluently, but with interruptions; fixation causing uneasiness. Every attempt at binocular fixation was followed by headache and nausea, as if an attack were impending.

Background of both eyes and field of vision normal.

Two days after the attack, patient had completely recovered.

In both eyes, V.=$\frac{15}{15}$.

R. E., Jaeger 1 from 3″–15″.

L. E., Jaeger 1 from 4½″–15″.

Muscular equilibrium of the eyes normal.

After thirteen days of complete health, another attack occurred under the same symptoms, and with the same course as described above, viz., *loss of vision, in the left eye dilated pupils, increased tension, while the background remained normal.* Restitution ad integrum on the following day.

On my advice, patient went to Pyrmont for four weeks, and afterwards to Scheveningen.

During his sojurn at Pyrmont, he had two attacks. The first set in on the second day after his arrival, with unabated violence ; the second occurred three weeks later, and was much milder. At Scheveningen, where patient remained five weeks, two attacks occurred. During their presence, the vision was not totally lost. Larger objects could be recognized, even at the height of the paroxysm, and the impairment of sight lasted only some hours. Towards evening, the sight and general health were restored, enabling him to leave his room.

In October, 1874, I saw him for the last time. He told me that, after his stay at Scheveningen, he had enjoyed excellent health for several months, and had thought his affection cured. But last May, another attack, preceded by considerable mental excitement, occurred. *The sight of the left eye was totally lost.* The whole field of vision represented a uniform dark surface. Photopsia and scotomata were absent. The blindness lasted about an hour. In the course of three hours, with the improvement of the general condition, the vision was completely restored.

This form of attack remained isolated. From that time it has happened that, after great mental exertion, or after a night spent in debauchery, he awoke in the morning with pain in the region of the left temple, while the temporal artery beat stronger, and the left eye was clouded. The objects, seen with this eye alone, appeared smaller and dim. Binocular fixation difficult. Absolute rest shortened the attacks to a couple of hours.

Examination showed normal condition of both eyes.

The study of this case led me to the conclusion that we had to deal with that form of vaso-motor neurosis which, under the name of hemicrania, has long attracted the attention of the profession; the scientific investigation of which, however, is of recent date.

I felt justified in drawing this conclusion from similar observations and experiences, made frequently enough upon myself.

In former years, I suffered from frequent attacks of most violent hemicrania, and am not yet quite free from them. The nature and the different phases of this affection I have studied with the interest engendered by personal suffering. From the beginning, I have paid the greatest attention to the questions referring to the condition of the eyes in the whole course of the paroxysm.

Before analyzing the physiological significance of intermittent blindness, I think it opportune to give the record of my own malady, as watched in the development of its various symptoms. Thus we obtain a basis for comparisons which may guide us in our further researches.

My first attack of hemicrania occurred in my twenty-fifth year of age, in November, 1865, at a time when, though in good bodily and mental condition, I was overfatigued by mental exertion. One morning, while reading, I suddenly observed that the words of the book, which lay open before me, began to flutter about, that the lines and letters ran into each other, stretching and distending themselves, thus performing the most various configurations. My sight, however, was perfectly clear and sharp. After a short time, scintillation arose before both eyes, so as to render fixation impossible, and a sensation of giddiness set in, as if the body, lacking support, swaying to and fro, was floating in the air. *In this state, I lost for one moment the power to find the proper word for the corresponding thought.* I knew very well what I wanted to say, but I was unable to find the proper expression. Soon afterwards I felt chilly through my whole body, and a dense fog seemed to be before my eyes, enveloping all objects. With closed eyes I had the most singular visual phenomena. At one time, the field of vision seemed to be dark, interrupted only by bright points, which, in perpetual motion, now conglomerated to larger masses, then divided, performing the strangest configurations; at another time, the field of vision became bright, and dark spots came in sight, which, like the so-called dissolving views, represented the queerest figures. After a while the sensation of giddiness gradually subsided; the fog before the eyes became clearer and more transparent. The right side of the head was freer. But, at the same time, left-sided headache set in, which, gradually increasing, reached the highest degree of violence, and was accompanied by intense pulsation of the temporal artery.

The paroxysm lasted the whole day, abating somewhat in the evening. On the following morning, all symptoms of the disease were gone. But there remained general exhaustion, and the head was so weak that every effort to read caused a sensation of vertigo.

From that time the affection was repeated at irregular intervals, and with varying intensity.

In the following notes, I give the results of my long-continued observations, which may claim a certain objectivity.

Every paroxysm, which, with a few exceptions, begins in the morning, is marked by its abrupt and unexpected appearance. The transition from the healthy to the pathological condition is not determined by any exciting causes or unhealthy influences. In full enjoyment of health I suddenly become aware of the air beginning to vibrate, and the objects around me growing pale. *This is the infallible fore-token of an attack.* This prodromic state may last a few minutes, or sometimes half an hour. It is followed by violent scintillation before both eyes, by dazzling, and a sensation as if the head were pressed in an iron ring. The room fills with fog, which always seems to descend from the ceiling. The fog is in perpetual motion, at first dark and uniform, then bright, and forming the most varying figures. The objects around me, and the floor under my feet, begin to waver. *Fixation is impossible; vision impaired. The face grows pale, the voice hoarse. The hands are cold. Both eyes are sunken. The pulse is small and hard, of normal rate. The respiration is not accelerated. Sensorium and hearing are intact. The sensibility is increased.* Besides, there is a general lassitude, a feeling of chilliness, and—in rare instances—nausea. Emesis, however, never took place. I artificially provocated it several times, thinking to check or, at least, lessen the attack; but only the reverse of my expectation occurred. The dizziness gradually subsides; fog and scintillation disappear from the right side of the head, and the entire violence of the paroxysm localizes itself on the left side.

This state is introduced by violent headache, which suddenly begins in the region of the left temple, and is soon followed by intense pulsation of the temporal artery. The latter feels like a hard cord, and appears in great windings under the covering skin. Hyperæsthesia of the face is of uncertain occurrence. Points of pressure and of pain in the sense of Valleix do not exist. Sometimes I obtained momentary relief by compressing the temporal artery, but at other times this procedure contributed only to increase the pain. Compression of the carotid is neither able to shorten the paroxysm nor to break its violence, or lessen it temporarily. Absolute rest in a dark room, if it does not afford improvement, gives, at least, some relief. Sleep is the only agent that sometimes shortens the paroxysm, which is aggravated by all intense impressions, and by increased congestion of the head; for instance, loud noises, commotion of the body, attempts at fixation, offensive or pungent odors, stooping, coughing, etc.

During the acute state of the paroxysm I am utterly unable to use my mind. I am not master of my own thoughts, and must perforce follow them in their disorderly course. Ideas crowding in the brain, following one another with bewildering rapidity. They cannot be checked nor scared away. It is as if some strange force had taken possession of the brain, compelling it to act in this incoherent manner.

The inability to find the right word for the thought, the want of recollection of the word to be pronounced, occurred since the first attack only once more, in October, 1876.

The improvement of the general condition is marked by the abatement of the feeling of chilliness. As soon as the body grows comfortably warm, remissions of the headache set in. The night-rest ends the morbid process.

When the paroxysms are severe, general fatigue and heaviness of the head remain through the following day.

The condition of the eyes is as follows: At the outbreak of the paroxysm, when vision begins to fail and scintillation sets in, *both pupils are abnormally dilated* and sluggish, both consensually and on reflex action.

In the further course of the paroxysm the condition of the pupils is not always alike and regular. In most instances the right pupil grows normal, or for a short time somewhat myotic, already when the left-sided headache begins, while the left pupil—the left side of the head always is affected—remains dilated during the whole course of the paroxysm.

Only when the latter subsides, the mydriasis gradually diminishes and entirely disappears towards evening, when the general health is improved. Sometimes when the paroxysm is slight, the mydriasis subsides in both eyes after a short time, when the temporal artery begins to pulsate. The pupils then become either normal or slightly myotic, but the myosis never lasts longer than a few minutes, and the pupils become normal.

As soon as the fog disappears from the right side, the retraction of the right eye also subsides. Generally this restitution takes place simultaneously with the restitution of the right pupil. During the whole course of the paroxysm the left eye remains more or less sunken, even if the paroxysm is slight.

Both eyes are very sensitive to light. But there is neither increased injection of the conjunctiva nor lachrymation. The movements of the lids and the intraocular pressure are normal during the whole paroxysm. The equilibrium of the associated muscles is affected in a particular manner. Ordinarily I am able to overcome, on fixation of an object at a distance of 8″, an adducent prism of 27°, and an abducent prism of 18°. At a distance of 15′ I overcome an adducent prism of 10°, and an abducent prism of 4°. At 8″ I overcome a prism of 6°, at 15′ a prism of 3°, with basis down or upwards. The results of a great number of experiments, made during the height of the paroxysm, are as follows: At 8″ distance, fixing a round dark spot of 5 mm. diameter, I overcome an adducent prism of only 12°, the fixation through a red glass very often gives crossed double images. At the same distance and fixing the same object, I overcome an abducent prism of 10°, a prism with basis down or upwards only of 3°. At 15′ distance, on fixing the flame of a candle, I overcome an adducent prism of 6°–8°, an abducent prism of 3°–4°; a prism of 2° with the basis down or upwards; but sometimes the latter prism produces vertical double images. The energy of the muscles only gradually grows normal, sometimes only on the third day after the attack.

The condition of the vision of both eyes is as follows: In the prodromic state vision is impaired in both eyes, but improves as soon as the sensation of giddiness subsides and the fog clears up. Then the vision of the right eye becomes normal, while that of the left remains impaired until the following day.

With M. $\frac{1}{9}$ my vision is $\frac{15}{15}$. Jaeger 1 is read with both eyes from $4\frac{1}{2}''$–10″. In the prodromic state of the paroxysm I see without glasses only Sn. CCLXX. at 15′; at 10′ Sn. 200 indistinctly. M.

remains the same. With $-\frac{1}{9}$ V. is $\frac{15}{50}$, resp. $\frac{15}{40}$ with both eyes together. Vision of one eye is always less, hardly $\frac{15}{50}$. After the occurrence of the one-sided headache, the right eye becomes very soon normal. Vision of the left eye fluctuates all the day long between $\frac{15}{40}$ and $\frac{15}{30}$, and is about $\frac{15}{20}$ towards evening. The examination with slightly blue glasses is very agreeable to the eyes and gives in many cases a higher degree of vision. As soon as the fog has cleared up and the scintillation subsides, I read with the right eye Jaeger 4, with +10 Jaeger 3 and some words of Jaeger 2. With the left eye I read Jaeger 6, with +10 some words of Jaeger 4. When the paroxysm is over, I read with the left eye Jaeger 4 and 3. The recovery is perfect only on the next day.

Every attempt at binocular fixation, made on the day of the hemicrania, is punished by increased violence of the paroxysm.

The field of vision is normal in both eyes. The sensibility to colors is but slightly diminished toward the blue and violet in the left eye.

The ophthalmoscopic examination shows, without exception: *In the beginning of the paroxysm, dilatation of veins, contraction of arteries in both eyes. This pathological change disappears in the right eye with the headache, but remains in the left eye during the whole day of the paroxysm.* The examination has been made partly by autophthalmoscopy, partly, for the sake of verification, by other oculists. The subjective visual phenomena are inconstant. The scintillations and the fog before the eyes have always been the true companions of the paroxysm, but the above-described bright points and dark spots in their various configurations sometimes were either absent or of short duration.

In the last years, when the attacks of hemicrania were more seldom and weaker, I have very often perceived, in the beginning of the paroxysms, these luminous and chromatic appearances exhibiting in my case all the colors of the rainbow which Liveing describes under the name of "fortification pattern" and illustrates with some drawings.* These colored spectral phenomena appear before both eyes, and always in the outer part of the field of vision.

The following communication, sent me by Prof. Du Bois-Reymond, of Berlin, on this subject was of great interest to me. "It was very remarkable to me that Liveing describes and illustrates in his book on 'Megrim,' under the name of 'fortification pattern' a subjective phenomenon of light, observed by many patients during hemicrania, which I had experienced myself once or twice before, and which occurred oftener since my attention was drawn to this fact, while I have been free of all other symptoms of the affection for at least fifteen years."

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* See Edw. Liveing: On Megrim, Sick-Headache, etc., London, 1873, pp. 13, 76, 83.

In order to complete the history of my malady, I will answer briefly the questions on the causes, the course, and the efficacy of the remedies applied. Great mental exertion was in my case the only cause of the affection. The course of my hemicrania is as follows :

From the day of its first appearance to the spring of 1870, the attacks have been very frequent and violent. In the spring of 1870, I began to suffer from chronic gastric catarrh, which lasted for about two years. In spite of utmost anæmia and general exhaustion (my weight sank from 150 to 114 pounds), I was altogether free from megrim. It set in again with my recovery ; the attacks having become weaker and the intervals longer.

Medication was of no avail. I have tried every form of treatment, from quinine to nitrite of amyl and the constant galvanic current without any benefit whatever.

Positive statements on the condition of vision in hemicrania are found in 38 of those 67 cases which E. Liveing has collected in his highly interesting work on Megrim. In these 38 cases, the affection of sight was observed partly in the prodromic state, partly during the course of the paroxysm. The affection of sight was caused partly by a central scintillating scotoma, partly by general obscuration of the field of vision, partly by hemiopia. In most cases there were subjective phenomena of light and dazzling.

Von Graefe speaks of real hemiopia, viz., anæsthesia of one optic tract, which often accompanies attacks of megrim, and distinguishes this form from the more frequent complication of megrim, the false hemiopia, viz., the half-seeing of single objects.*

It may be that the morbid process which is known under the name of "*Listing's scintillating scotoma*" ("Flimmerscotom") is only a symptom of megrim. At the Ophthalmological Congress of Heidelberg, in the discussion of Prof. Foerster's paper on "*Amaurosis partialis fugax*," Mannhard and Schirmer expressed their opinions, based upon self-observation, that the scintillating scotoma was to be regarded only as a concomitant phenomenon of megrim. Also Liebreich mentioned that some of his patients had complained of it in connection with megrim.*

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* See : Vorträge aus der v. Graefe'schen Klinic, Zehender's Klin. Monatsbl., III. Jahrgang.

In one case of *amaurosis partialis fugax*, observed by R. H. Derby, there was lateral hemiopia of both eyes. The disturbance of sight lasted for about twenty minutes, and was followed by headache, dizziness, and vomiting, sometimes also by epileptiform seizures.†

The bilateral form of hemicrania has been observed several times by Liveing and once by Dr. Zürchner. Dr. Zürchner described his case under the name of Amphicrania. It showed a dilatation of both pupils and of the blood-vessels of the head, and episcleral injection. In cases of hemicrania, the vision may also remain intact, as is proved by the case of Dr. Lebert, cited by Liveing.

For the following case of *amblyopia hemicranica* I am indebted to the kindness of my friend Dr. H. Delacroix, of Reims. The statements of the condition of the eyes during the attack are the more valuable as they are the results of self-observation of a competent oculist.

H. D., 33 years old,‡ suffered from his 16th year from temporary attacks of cardialgia. They disappeared in his 26th year, but were followed by dermalgia of the lower extremities. The attacks were almost always introduced by a painful sensation in the region between the fourth and sixth vertebræ. During the intermissions, slight cutaneous anæsthesia of the lower extremities remained. In the course of three years, the diameter of the pupils became inequal. The left pupil was twice as large as the right one and had a slight accommadative paresis ($\frac{1}{A}=\frac{1}{8}$ to $\frac{1}{10}$).

In the year 1873, the first attack of hemicrania set in, repeated, in irregular intervals, about twenty times in the following three years. Each attack was attended by amblyopic phenomena, and never lasted more than forty-five minutes.

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* See: Klin. Monatsbl. für Augenhlkde., November–December, 1869.

† See: Nagel's Jahresbericht für Ophth., 1872, p. 370.

‡ These notes have been written in winter of 1876.

The predisposing causes were over-exertion, insufficient sleep, low barometer. The paroxysms occurred every hour of the day. Their course was as follows:

In the midst of perfect health, there appeared, either on the right or on the left side, but never on both sides simultaneously, an obscuration, then a blank spot, a deficiency in the field of vision, a kind of scotoma which, at first small, soon increased rapidly. If he was walking on the street, the scotoma first obscured only a part of the face of any one who happened to pass, the ear or head of a dog, but it soon prevented the perception of larger objects, provided, however, they were on the side of the affected field of vision. Violent left-sided headache was at times the forerunner, at others, the companion of the scotoma, which was associated with very peculiar photopsia, consisting in the subjective perception of very bright and dazzling zigzag-shaped flashes, occupying only a small portion of the obscured field of vision, and being mostly of a gorgeous bluish-yellow color, sometimes with a tint of red and sky-blue. This phenomenon was also perceived with closed eyes, and not modified either by bright or moderate illumination. It was more brilliant in the dark and disappeared only with the disturbance of sight.

The last attack is described as follows: On the 11th of November, 1875, at eleven o'clock A.M., an attack seized me while walking in the street. The weather was rainy and stormy. At first left-sided headache set in and was soon afterwards followed by an irregular scotoma in the right half of the field of vision of both eyes. It had all the properties of the above-described photopsia.

Re-examination of the eyes showed: 11h. 15m.—In the left half of the common field of vision, S. = 1 in each eye.

Accommodation of the left eye $= \frac{1}{12}$. $\frac{1}{A}$ of the right eye $= \frac{1}{7}$. Almost complete right-sided hemianopsia. Transitory obscurations also appear in the left half of the field of vision.

11h. 20m.—Hemianopsia and scintillation have reached their maximum.

11h. 40m.—Headache diminished. Scintillation vanished.

11h. 45m.—All symptoms of disease have disappeared.

The course of paroxysm was this time weaker and shorter than usual.

On the further concomitant symptoms of hemicrania, I find the following statements:

Du Bois-Reymond,* who made the pathology of megrim the subject of special study in his person, observed that during the paroxysm the temporal artery of the affected side felt like a hard cord, while it was normal on the left side. The face was pale and wrinkled, the right eye was retracted and red; its pupil dilated. Toward the decline of the paroxysm, the right ear was red, and experienced a lively sensation of heat, which was also perceptible to the hand.

Bruner † observed in his own megrim, and in that of his mother, the same symptoms as described by Dr. Du Bois-Reymond.

Piorry ‡ observed in hemicrania a contraction of the pupil of the affected side.

Samelsohn § mentions a case of hemicrania, in which, in some attacks, there was a contraction of the pupil and pericorneal injection of the affected eye, while in other attacks the pupil was contracted, but there was no injection.

Eulenburg ‖ found, in several cases of hemicrania, contraction of pupil on the affected side, toward the decline of the paroxysm.

Moritz Rosenthal ¶ describes a case of megrim, in which the pupil of the affected side was dilated.

O. Berger ** describes a case of megrim, in which the condition of the eyes is stated as follows: Under the symptoms of vaso-motor paralysis of the right side of the face, the fissure of the lids of the right eye becomes perceptibly narrowed, the globe is retracted, the upper part of the right cornea covered by the lids, even when the eyes are widely open. Conjunctiva is injected, the eye waters. The right pupil is contracted. Reaction on light is almost lost.

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*See: Zur Kenntniss der Migräne. Arch. für Anatomie und Physiologie, 1860, pp. 461–468.

† See: Zur Pathologie des Sympathicus von Dr. Alb. Eulenburg und Dr. Paul Guttmann, p. 20.

‡ See Liveing, p. 300.

§ See: Von Graefe's Archiv für Ophth., B. XXI. 3, p. 56.

‖ See his Lehrbuch der functionellen Nerven-Krankheiten.

¶ See his Handb. der Diagnostik und Therapie der Nervenkrhten.

** See: Nagel's Jahresb. f. Augenhlkde., 1874, p. 337.

E. Fränkel[*] describes the symptoms of his own megrim. During the attack the pupil of the suffering side is contracted, the contraction is simultaneous with the paroxysm, and is not preceded by dilatation. The reaction on light is prompt; the dilatation on exclusion of light, slow and incomplete. Atropia is of slight effect. Contraction of the fissure of the lids Fränkel did not observe in his own case, but in others.

In a case of left-sided megrim, Fränkel observed a permanent contraction of the left palpebral fissure and of the left pupil, while the reaction on light and the further condition of the eye were normal. The left eye showed M. $\frac{1}{30}$, with normal vision. The right eye was emmetropic.

Of the ophthalmoscopic condition of the eyes in cases of hemicrania, I find the following statements:

Liveing[†] had an opportunity for making an ophthalmoscopic examination in one case of hemicrania in the beginning of the paroxysm, when the blind stage had begun. The pupils were fully dilated. Both the retina and optic papilla presented a healthy appearance. The latter was well defined; if anything, rather pale, but certainly exhibited neither well-marked hyperæmia nor anæmia; the retinal vessels appeared normal; the veins, perhaps, were rather large. There was no difference in these respects between the two eyes.

On the following day, when all traces of the attack had passed away, the examination was repeated, but no alteration in the appearance of the parts could be detected.

Möllendorf[‡] says in regard to his case of hemicrania:

"During the attacks, the background of the eye of the suffering side was of a bright scarlet-red, the optic papilla red and œdematous, the arteria and vena centralis retinæ enlarged; the latter knotty and very tortuous, and much darker in color than at other times. The other eye had a normal fundus."

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[*] See: Nagel's Jahresb. f. Augenhkde., 1874, p. 338.

[†] See: On Megrim, p. 80.

[‡] See: Ueber Hemicranie. Archiv für patholog. Anatomie, Bd. LXI., H. 3 u. 4, pp. 385–395.

The ophthalmoscopic examination in the case of O. Berger, made by H. Cohn, gave the following result: Retinal vessels absolutely normal. No difference between the two eyes.

E. Fränkel found no ophthalmoscopic difference between the two eyes in his case of left-sided hemicrania, combined with left-sided ptosis.

On the condition of the intraocular pressure in megrim, I find the following highly interesting communication of Woinow.*

He examined with the ophthalmometer the curvature of the cornea of two patients who suffered from megrim, during and after the attack. During the paroxysm, the curvature of the cornea of the suffering side was smaller in both patients. In one case, the corneal radii were larger in all meridians by 0.416 mm.; in the other case, there was also an enlargement of the radii, but not so uniform. The greatest increase with 0.38 mm. was in the vertical meridian. "While," he proceeds, "I draw no positive conclusions from these two cases, I nevertheless am inclined to suppose that the intraocular pressure might have been increased here during the affection. In the eye of the unaffected side, there was no abnormity."

Finally I may be allowed to mention a verbal communication of Prof. Coccius, to the effect that he had observed many cases of hemicrania which had afterwards led to glaucoma. In some cases of hemicrania, he is disposed to regard the affection only as a prodromic stage of glaucoma.

As a very striking example, he quoted Prof. Ritterich, who had suffered for a long time from hemicrania, until he was seized with glaucoma.

The question as to the nature of hemicrania has only recently been investigated in a strictly scientific way. Du Bois-Reymond, led by observations made on his own person, came to the conclusion "*that in his megrim a tetanus takes place in the muscular coats of the vessels of the affected half of the head; in other words, a tetanus in the territory of the cervical portion of the right sympathetic.*

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*See his Ophthalmometrie, Wien, 1871, p. 68.

"The condition of the temporal artery, the bloodlessness of the face, the sunken-in state of the right eye, show that the muscular coats of the vessels of the affected half of the head, so far as they are accessible to observation, are persistently contracted. From the condition of the ophthalmic artery, we infer a like condition of the remaining branches of the internal carotid, and presume that it is the same for the vertebral artery.

"From the fluctuations of the blood-pressure in the brain, which probably are the consequence of the alternate contraction and relaxation of the muscular coats of the vessels, a sort of clonic spasm, we readily understand (on the principle of Wollaston's theory of sea-sickness), whence the nausea arises which accompanies megrim. The lowering of the blood-pressure in the visual apparatus may perhaps, in a similar manner, explain the scintillation before the eyes which is often observable in megrim, as also from the use of digitalis.

"However this may be, it is quite clear whence the redness proceeds, and the increased warmth in the region of the ear which attends the abatement of the headache. It is the same kind of phenomenon as that which we observe when we come into a warm room after staying in the cold. The smooth muscular fibres may become exhausted, of course, like the striped fibres. When the irritating causes which kept the muscular coat of the vessels so long in a state of spasm abates, there follows from the over-exertion a state of exhaustion, in which the vascular walls yield more than they otherwise would to the lateral pressure. The effects are the same as those of section of the vaso-motory nerves—loss of tone of the vascular muscles, manifesting itself by redness and increased temperature.

In the foregoing description of the affection, there is one condition that does not accord with our theory, namely, the presence of redness of the conjunctiva during the attack. But this may, perhaps, be explained in this way: The muscular coats of the conjunctival vessels are sooner exhausted, or their spasms begin at an earlier period than takes place in the others here concerned.

"A tonic contraction of the muscular tissue of the vessels on one side of the head can have no other cause than *a persistent excitation, a tetanus of the cervical portion of the sympathetic nerve on the same side.* The seat of such a tetanus again must be sought in the corresponding half of what is termed by Budge and Waller the 'regio cilio-spinalis.'

"That in my megrim a tetanus of the cervical portion of the right sympathetic takes place is proved by the fact that the pupil of the affected side is dilated during the attack.

"It now only remains to consider whether this tetanus simply accompanies the megrim or is the megrim itself, that is to say, the immediate cause of the headache.

"The latter view takes for granted that the tonic contraction of the smooth muscular fibres is not less painful than that of the striped fibres, as in cramps of the legs, tetanus from electrical tetanization, and the like. The pains of labor and of colic support this view beyond a doubt. It is readily understood why, when the muscular tissue of the vessels on one side of the head is affected by tetanus, headache will be felt on one side only.

"The muscular pain which accompanies tetanus proceeds probably from pressure upon the sensitive nerves distributed within the muscles. This pressure, and consequently the pain, must increase if the tetanized muscles are more strained, as we find in the case of leg-cramps, when the gestrocnemii are stretched, either by means of the antagonistic muscles, or by supporting the weight of the body on the ball of the foot. The same thing takes place in tetanus of the muscular coats of the vessels through the augmentation of the lateral pressure of the blood in the vessels. This supposition explains why the pain increases with any augmentation of the blood-pressure in the head."*

Later, Möllendorf, apparently without knowledge of Du Bois-Reymond's theory, judging from his own observations of the symptoms of hemicrania, asserted that: *Hemicrania is a partly typical, partly atypical, one-sided loss of power of the vaso-*

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* See: Du Bois-Reymond, Zur Kenntniss der Migräne, loc. cit.

motor nerves, the carotid artery causing a relaxation of the arteries and an arterial fluxion toward the brain. This loss of power of the vaso-motory nerves may occur in different parts of the body, transmitted by conduction from the cervical portions of the sympathetic.

After setting forth the various features of the malady, Möllendorf proceeds:

"The same fulness, pain, and tension felt in the brain and in the skull are also felt in the eyeball, the movements of which are greatly impaired. They also are felt in the parts of the head which are supplied by the internal carotid, and where, from their small extensibility and rigid surroundings, a trifling increase of their fluid contents would be felt as tension.

"Concomitant sensations are found in the auditory nerve as tinnitus and sensitiveness to loud noises; in the optic nerve, as a bright rotating star and photophobia; the pupils are contracted, and the contraction is equal on both sides.

"The ophthalmoscope also shows an arterial fluxion and venous engorgement.

"During hemicrania, the rate of the cardiac pulsations was considerably lowered; the pulse rate, from 72–70 beats per minute, sank to from 56-48 beats. The radial artery was small and contracted, whilst in the carotid and temporal artery a soft, broad pulse was felt. The respiration was, corresponding to the pulse-rate, retarded, superficial respirations alternating with deep groans.

"In regard to the cause of this fluxionary condition, we know that, as sensory nerves can excite motor nerves by reflex action, so the irritation of the sympathetic nerves, either by mental emotion or by physiological tetanization of specific organs, may occasion a short hyperenergy of the muscular tonus of the vessels, which is followed by a more lasting anenergy. In this respect the effect of alcohol offers a remarkable parallel to the coarse of hemicrania; for the headache from drink never arises during the first stage of intoxication, but when its effect has passed off, and an unpleasant relaxation has succeeded the agreeable excitement."*

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* See: Möllendorf, Ueber Hemicrania, loc. cit.

A third form of vaso-motor theory on megrim, put forward by Dr. Latham, of Cambridge, may be briefly mentioned here. He believes that: "a morbid activity of the sympathetic nerve, in consequence of a defective control or inhibition by an exhausted or enfeebled cerebro-spinal system, is the primary cause of the malady. The effect of this morbid activity in the cervical region of the sympathetic is to cause a contraction of the vessels of the head and anæmia of the parts they supply, and this he regards as the immediate occasion of the paroxysm and the cause of the earlier symptoms, and particularly of the disorder of sight; while he refers the headache to a secondary hyperæmia, which follows the exhaustion of this morbid activity."

The analysis of Du Bois-Reymond's and Möllendorf's theories has made us acquainted with two forms of hemicrania, the definition of which may be carried through, according to the strict rules of physiological science. As *hemicrania sympathicotonica*, in the sense of Du Bois-Reymond, we have to regard all those cases in which we observe the symptoms of a spasm in the muscular coats of the vessels, an arterial tetanus in the cervical portion of the sympathetic; whereas, as *hemicrania neuro-paralytica* or *angio-paralytica* we have to regard all those cases in which, according to Möllendorf, a reverse condition takes place, viz., dilatation of the vessels, arterial hyperæmia caused by a paralytic condition of the vaso-motor nerves.

Latham's hypothesis of the morbid activity in the cervical portion of the sympathetic may be regarded as a sort of compromise between the extremes of Du Bois-Reymond's and Möllendorf's theories.

After having thus obtained a scientific basis for our conception of hemicrania, we will attempt to interpret, at first on physiological principles, all those symptoms which are pathognomic in my own case, in order to be enabled to apply the obtained results to the investigation of the case of intermittent blindness.

From the description of the symptoms in my own affection, the latter appears as hemicrania sympathico-tonica, bilateral in the prodromic stage.

The course may possibly be explained in the following manner: Either the same cause of irritation affects at the same time both cervical portions of the sympathetic, without, however, producing the same effect. The reaction in the right cervical portion of the sympathetic is weak and short, whereas it is violent and lasting in the left. Or the primary seat of irritation is only in the left cervical portion of the sympathetic, but transmitted from one side to the other, whereby the secondary irritation, being weak, subsides after a short time. The transmission of the irritation can easily take place at one of the central points of the vaso-motor nervous system, if, following Vulpian,* we do not admit the existence of only one vaso-motor centre, pedunculus cerebri, or thalamus opticus.

The supposition that the predisposing cause of megrim in my own person is based upon a tetanus of the sympathetic is confirmed if we examine the symptoms of the malady according to their physiological value.

The sensation of giddiness and dizziness, in the beginning of the paroxysm, is the first symptom of the fluctuations of the blood-pressure in the brain, which are the consequence of the contractions of the muscular coats of the vessels, that occur as a sort of clonic spasm, alternately enforced and reduced. In a similar manner the scintillation may be explained by the reduction of the blood-pressure in the substance of the optic nerve (Du Bois-Reymond).

The temporary obscurations of the field of vision, the temporary impairment of sight, and the subjective visual phenomona are in direct relation to the anæmia of the brain, and caused by transitory derangements of the circulation of blood in the retina and optic nerve. They are the same as in many other cases of anæmia of the brain, where we also observe more or less pronounced disorder of sight, either of a transitory or permanent nature.

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* See: Leçons sur l'Appareil vaso-moteur, par A. Vulpian. Paris, 1875, Tome 1, p. 261.

A further proof of this view is found in the fact that the scintillations and obscurations disappear very soon in the right eye, whereas they last long in the left. This depends upon the localization of the morbid process on the left side of the head. As soon as the tetanus of the muscular coats of the vessels here also subsides, and the circulation of blood returns to its normal condition, the vision of the left eye improves, and the scintillation gradually diminishes.

The paleness of the face and the condition of the temporal artery may be owing to the decrease of the circulation of blood consequent upon the contraction of the muscular coats of the vessels. The concomitant chills may also be only a consequence of the temporary abnormal irritation of the vaso-motor nerve-fibres which are distributed within the cervical portion of the sympathetic. All the blood-vessels of one-half of the head being contracted, the medulla oblongata receives a smaller quantity of blood; the temporary anæmia of the medulla acts stimulating on the vaso-motor nervous centre, located there, by which the well-known phenomena of the chills are procuced, viz., tetanus of the smallest arteries of the skin.*

An explanation of the pain accompanying hemicrania was given by Du Bois-Reymond to this effect, that it is, perhaps, the tonic spasm of the smooth muscles of the vessels which is felt as pain, as, for instance, in cases of leg-cramps, of labor-pains, etc. Eulenburg† has advanced another explanation of the pain accompanying megrim. His explanation would readily account for the cutaneous hyperæsthesia which I have often observed in my own person. He thinks that the variations in the afflux of the arterial blood, especially the temporary anæmia of the suffering side of the head, may cause irritation of sensory nerves of the head and the hemicranic neuralgia. That sensory nerves may be intensely stimulated by changes of calibre in the blood-vessels, especially if these changes occur abruptly; and that they react by the sensation of pain, we observe in the various forms of neuralgia (prosopalgia, ischias, etc.). Also the neuralgias consequent upon herpes zoster may probably be derived from the same source, as, in general, anomalies of circulation, especially anæmia, are considered to be the most important cause of neuralgic affections.

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* See: Eulenburg and Guttmann, loc. cit., p. 4.

† See his Lehrbuch der functionellen Nerven-Krankheiten und die Pathologie des Sympathicus v. Dr. A. Eulenburg und Dr. Paul Guttmann, p. 21.

In regard to the oculo-pupillary phenomena, I observed in my person, as Du Bois-Reymond in his case, a retraction of the left eyeball during the whole duration of the paroxysm, and a retraction of the right eyeball in the beginning of the paroxysm.

This oculo-pupillary symptom does not correspond to a tetanus of the oculo-pupillary fibres of the sympathetic, but shows just the reverse condition, viz., a paralysis of the vaso-motor fibres. We know that in animals, especially in cats, when the sympathetic is cut, *contraction of the pupil, narrowing of the fissure of the lids, and retraction of the eyeball into the orbit* ensue; whereas, when the proximal end of the divided sympathetic is tetanized, *dilatation of the pupil, considerable exophthalmus, and enlargement of the fissure of the lids* follow.

Du Bois-Reymond, with whom I have been in communication in reference to this contradiction, has favored me with his views on this matter, in a letter he kindly permitted me to publish.

"You are quite right with your question; there is a kind of contradiction between the retraction of the eyeball in my case, and in the exophthalmus consequent upon the tetanization of the sympathetic, which has been observed in cats. But I do not consider explanation impossible. First, it is to be borne in mind that the exophthalmus in tetanizing the sympathetic is not based upon spasm of the muscular coats of the vessels, but only upon contraction of smooth muscular fibres, which spread over the fissura orbitalis inferior, as described by H. Müller. I do not know if similar fibres have also been observed in man. Even if such fibres should have been detected in man with the microsope, there still remains to be proved that, in spite of the very different arrangement of the surrounding parts, they act in the same manner as in cats. Secondly, we must consider that, in tetanizing the sympathetic, even in cats, two kinds of effect of an opposite nature take place: 1st, the contraction of those smooth muscles which push the eyeball forwards; 2d, the constriction of the blood-vessels in the orbit, in consequence of which the eye seems to be sunken. Also in man, exophthalmus could be the consequence of tetanization of the sympathetic, and yet this result could be out-balanced by the emptying of the blood-vessels. The retraction of the eyeball by tetanizing the sympathetic may perhaps find its counterpart in the exophthalmus by paralysis of the sympathetic, in cases of Basedow's disease. I must, of course, confess to have overlooked these difficulties in my paper, but at that time the action of the sympathetic on the position of the eyeball was unknown to me. Besides, there exists another similar contradiction in my own observations, which I mentioned there, viz., the injection of the conjunctiva, notwithstanding I have maintained that there is a tetanus in the territory of the cervical portion of the sympathetic. But the matter could possibly be explained in this manner, that, while tetanus takes place in certain fibres of the sympathetic, paralysis occurs in others, and among the latter we have to class as well the vaso-motor nerves of the conjunctiva as those nerves which belong to the smooth muscles, spreading over the fissura orbitalis inferior."

The bilateral mydriasis in the beginning of the paroxysm must be regarded as a phenomenon of irritation, existing at the beginning in both cervical portions of the sympathetic, but disappearing soon in the right. The consequence is that, as soon as the right side of the head becomes relieved, the mydriasis vanishes, and is followed either by the normal condition of the pupil, or by transitory myosis. Either of these phenomena will mostly depend upon the degree of irritation in the corresponding cervical portion of the sympathetic, and upon the degree of the subsequent exhaustion.

The derangement in the left cervical portion of the sympathetic lasts longer, as the durations of the mydriasis of the left pupil shows. It subsides when the height of the paroxysm is over, and vanishes entirely when general improvement sets in. The reason for never having observed left-sided myosis at the end of the severe attacks of hemicrania may be that the improvement was gradual and slow, and that, in the mean while, the oculo-pupillary fibres of the sympathetic gradually recovered from the condition of irritation, without incurring the reverse condition of exhaustion.

The disturbance of equilibrium in the associated muscles, and the accommodative asthenopia, observed in my case during the duration of the paroxysm, are only the consequences of the general depression.

The ophthalmoscopic appearances of my left eye, which, on repeated examination, showed *a contraction of arteries and dilatation of veins*, may be explained as a condition consequent upon the irritation of the sympathetic, and the partial anæmia of the brain.

The retinal arteries are under the influence of the sympathetic. But whether the innervation is regulated exclusively by the sympathetic, or whether the fifth pair also participates in it, and if so, which part either of these motors takes in the regulation of the circulation of the retina, this question is difficult to answer at the present state of our knowledge of the innervation of the retinal blood-vessels. Leber and Schöller* claim to have observed a distinct contraction of the retinal arteries in tetanizing the sympathetic. Leber experimented on rabbits, Schöller on cats. *Dilatation of the veins has not been observed in these experiments.*

We know, however, from many clinical observations *that pathological contraction of the arteries almost always coincides with a distinct dilatation of the corresponding veins.*† Among others, Alfred Graefe, in his remarkable case of ischæmia retinæ, has also drawn the attention to this fact. We may further cite the observation of Coccius, to the effect that, during syncope, the calibre of the arteries was greatly reduced, while the veins were dilated.‡

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* See: Th. Leber, Die Circulations- und Ernährungsverhältnisse des Auges. Handbuch der gesammten Augenheilkunde von Graefe und Sämisch, B. 2, 1. Hälfte.

† See: Stellwag von Carion, Der intraoculäre Druck und die Innervationsverhältnisse der Iris. Wien, 1868.

‡ See: Coccius, Der Mechanismus der Accommodation. Leipzig, 1868.

The investigations of Adamük seem to vindicate a direct dependence of the hyperæmia of the veins upon the tetanization of the sympathetic. If an electrical current is applied to the sympathetic of animals under the influence of curare, in the region between the two inferior cervical vertebræ, the ophthalmoscopic examination shows, according to Adamük, *contraction of the arteries and widening of the veins.**

The experimental phenomena are corroborated by observations in my own case.

The analysis of the symptoms in my own case has given full support to our supposition that we have to deal here with that form of hemicrania which, according to Du Bois-Reymond, depends *upon an irritation of the corresponding cervical portion of the sympathetic.* Now we are arrived at the last part of our investigation: we have to examine into the nature of the derangement of innervation underlying the case of the intermittent blindness.

A comparison between the phenomena of my own hemicrania and those of the intermittent blindness shows an essential difference in the following points only.

In my case.	*In the case of intermittent blindness.*
1. Paleness of the face. Chilliness. Pulse normal, small, hard. Respiration and action of the heart normal.	1. Face highly flushed, covered with profuse perspiration. Palms warm to the touch. Radial pulse 90, full, strong. Respiration and action of the heart accelerated. Temperature of the body raised.
2. Conjunctiva of lids and eyeball normal.	2. Hyperæmia of conjunctiva of lids and eyeball.
3. Eyeball sunken.	3. Slight exophthalmus.
4. Intraocular pressure normal.	4. Intraocular pressure increased.

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* See: Adamük, Zur Lehre vom Einflusse des Sympathicus auf den inneren Augendruck, Med. Centralblatt, 1867, No. 28.

In my case.	*In the case of intermittent blindness.*
5. Vision impaired.	5. Vision reduced to quantitative perception of light.
6. Arterial anæmia, venous hyperæmia of retina.	6. Background of eye normal.

Let us now see what will be the result of a closer examination of these differences in the picture of the intermittent blindness.

The congestion of the blood-vessels, the flushing and increased perspiration of the face, the hyperæmia of the conjunctiva of the lids and the eyeball, are probably the effects of a paralysis of those vaso-motor nerve-fibres of the blood-vessels of the head which are contained within the cervical portion of the sympathetic.

We know, however, from other observations, that irritation of the oculo-pupillary fibres of the sympathetic often coincides with a paralytic condition of the vaso-motor fibres.

Among others, we have the highly interesting observation of Dr. P. Guttmann,* in whose case the vaso-motor symptoms entirely corresponded to those which are observed in animals after the division of the sympathetic, when the vaso-motor fibres become paralyzed; while the oculo-pupillary symptoms were similar to those which are observed in cases of irritation of oculo-pupillary fibres of the sympathetic.

Guttmann's opinion on this matter is as follows:

"Such a condition may be easily explained according to physiological principles in those rare cases in which the affection of the sympathetic is based upon a central cause (disease of medulla colli), the centres of the vaso-motor and oculo-pupillary fibres being located separately. Thus we are able, as was first proved by Cl. Bernard, to produce the vaso-motor and oculo-pupillary symptoms of paralysis each independent from the other; the former by cutting the ascending cord of the sympathetic of the chest, alongside the vertebral column, between the second and fourth ribs; the latter, by cutting the anterior roots of the first two spinal nerves. But also in those cases, where derangements of innervation of the sympathetic are produced by mere mechanical peripheric causes (pressure and the like), there is nothing to be surprised at, if one kind of fibres is brought into a paralytic, and the other into an irritative condition. There are too many examples in the pathology of nerves, where, in mixed nerve-trunks, there exist either only sensory or only motor disturbances, and still further, where opposite conditions co-exist in the same nerve, in the sensory fibres—diminished and increased sensation (anæsthesia dolorosa); in the motor fibres—diminished and increased motion, (paresis or paralysis, with spasm and paralytic contraction)."

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* See: Zur Pathologie des Sympathicus, Berliner Klinische Wochenschrift, 1875, No. 32.

Vulpian * gives another explanation of the peculiar fact that, in conditions of irritation of the sympathetic, besides the symptoms of irritation of the oculo-pupillary fibres, there exists a paralytic condition of some vaso-motor fibres.

He says: "We have seen that tetanization of the vaso-motor nerves brings about a contraction of the blood-vessels, and another result could, *a priori*, not have been produced. The vessels are provided with circular muscular fibres, the contraction of which can only be followed by a reduction of the calibre of the blood-vessels.

"The experiments, however, have made us acquainted with the following fact: There are nerves belonging to the class of the vaso-motor nerves, which, if tetanized, cause by centrifugal action a dilatation of those vessels which are under their influence.

"We are indebted for the knowledge of these nerves to Cl. Bernard. We may call them *vaso-dilator nerves*, in contrast with the *vaso-constrictor nerves* which we have considered heretofore."

After citing the experiments relative to this question, Vulpian proceeds:

"The experiments of Cl. Bernard have demonstrated that there are nerves, the tetanization of which immediately produces a dilatation of the blood-vessels. The *corda tympani* is a type of this class of vaso-dilator nerves."

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* See: Leçons sur l'Appareil vaso-moteur. Tome 1, p. 146 and ff.

Of the various thories of the nature of the vaso-dilator nerves, we will mention the one which is set forth by Vulpian himself.

"The vaso-dilator nerves are presumed to possess a kind of inhibitory action (une véritable action d'arrêt) on the vaso-constrictor nerves."

To illustrate this fact, Vulpian points to the well-known action of the vagus on the heart. "If an electrical current is applied to the peripheric end of the divided vagus, the movements of the heart are stopped, and the latter remains for some moments immovable, in the state of diastole, flabby and almost paralytic. The tetanization of the peripheric end of the vagus seems to produce here a modification of the nervous ganglia of the heart, in consequence of which the action of these nervous centres is stopped for some time, and paralyzed, which is followed by an interruption of the normal rhythmical movements of the heart; the heart remains inactive until the inhibitory influence of the vagus has been discontinued.

"The same condition probably takes place in the blood-vessels. Whether we have to deal here, according to Cl. Bernard, with a condition similar to what is known in physics as interference of light, must be left undecided. Anyhow, some nerves may have a similar influence on the vessels as the pneumogastric nerve on the heart. The vaso-constrictor nerves are in continual activity; the contractile coats of the vessels are normally never at rest, but in a state of medium contraction, which is known as vascular tonus. The vaso-dilator nerves are supposed to arrest, if tetanized, this tonic condition, paralyzing the vaso-constrictor nerves. The vascular tonus is discontinued; the vessels, arteries, veins and capillaries are widened only by the blood, which alone causes dilatation of the vessels."

The hyperæmia of the conjunctiva of the eyeball and the lids may be explained according to the view of Du Bois-Reymond, as given above.

The increased action of the heart, the acceleration of the pulse, result from the irritation of the cervical portion of the sympathetic. "In the tract of the cervical portion of the sympathetic, there are distributed the excito-motor nervous fibres of the heart, the nerves accelerating the action of the heart, which come from the central nervous system. If the cervical portion of the sympathetic is tetanized, the pulse-rate increases (v. Bezold); a condition of irritation in the cervical portion of the sympathetic explains, therefore, in a very satisfactory manner the increased contraction of the heart." *

The increased respiration is only a reflex action consequent upon the pain.

The exophthalmus is but the consequence of irritation of the sympathetic. In the experiment exophthalmus is produced by tetanizing the cervical portion of the sympathetic, in consequence of the contraction of the smooth orbital muscle, discovered by H. Müller, which, innervated by the sympathetic, is the antagonist of the musculus retractor and is able to draw the eyeball forth.

The increase of the intraocular pressure is also closely connected with the cause of the morbid process, the tetanus of the cervical portion of the sympathetic. According to Adamük,† tetanization of the sympathetic of the cat at first produces an increase of the intraocular pressure, which gradually assumes a normal condition, sometimes still during the tetanization, in most cases after it. The same observation has been made by v. Hippel and Grünhagan, who differ from Adamük only in the explanation of the phenomenon. Also Wegener‡ feels justified by his experiments in assuming that "the normal intraocular pressure is influenced and regulated by the vaso-motor sympathetic nerves of the blood-vessels of the iris and choroid, and that the cause of the increased intraocular pressure in glaucoma is based upon a pathological irritation of the sympathetic nerves of the blood-vessels of the eye."

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* See: Die Pathologie des Sympathicus, p. 52.

† See: Zur Lehre vom Einflusse des Sympathicus, l. c.

‡ See: Experimentelle Beiträge zur Lehre vom Glaucom. Von Graefe's Archiv für Ophth., B. XII., Abthl. 2.

Thus far we have succeeded in demonstrating: that the deviating phenomena in the case of intermittent blindness are either perfectly consistent with our supposition that the morbid process is based upon a tetanus of the sympathetic, or that they are a postulate of a tetanus of the sympathetic. We cannot pursue the way of physiological inquiry in regard to the last phenomenon—the intermittent blindness—which is left to our consideration. In order to explain it we have to recur to conjectures and hypotheses, which only mantle our ignorance. In the present condition of our knowledge it is impossible to explain the connection which exists between the temporary loss of vision, being only one symptom of the morbid process, and the affection of the sympathetic. In the course of our investigation, we have had occasion to become acquainted with the fact that hemicrania is in most cases followed by more or less pronounced impairment of vision. In some cases there existed morbid alterations of the background of eye, which gave a material basis to the impairment of sight. In the case of intermittent blindness, the ophthalmoscopic appearances are negative. This fact is not inconsistent with our assumption that the morbid process results from a tetanus of the sympathetic. Anyhow, there are cases of tetanus of the sympathetic where the retinal circulation undergoes no change. This fact is not only corroborated by clinical observation, but also by experiment. The recent experimental investigations of Klein and Svetlin "*on the influence of the sympathetic upon the circulation in the fundus of the eye*"* must be considered from this point of view.

We have certainly to deal here with a complicated process, with reflex actions, which modify the molecular nature of the optic nerve itself, causing changes of the nervous substance that baffle our observation. To put forth a conjecture as to the part which the sympathetic plays in this case is the more difficult as we do not possess any positive notion of the course which the nerves of the blood-vessels take within the brain.

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* See: Psychiatrische Studien in der Klinik des Prof. Leidesdorf. Wien, 1877.

ABSTRACTS MADE FROM THE OPHTHALMOLOGICAL LITERATURE PUBLISHED IN THE UNITED STATES OF AMERICA, DURING THE YEAR 1877, AND THE FIRST SIX MONTHS OF 1878.

By CHAS. S. BULL, M.D., of New York.

Pulsating Tumor of Orbit Resembling True Aneurism; Ligation of Common Carotid; Subsequent Removal of Tumor; Recovery. Frothingham.—*Amer. Jour. Med. Sciences*, Jan., 1877.

Patient was a woman, æt. 35. Exophthalmus of left eye for three years, and when last seen, the eye moved with each pulsation. Loud bruit heard over the eye and temple, which ceased when common carotid was compressed, and the eye receded. The tumor showed at external angle of orbit, and felt like a soft, elastic, pulsating tumor. No dilatation of pupil, V. much diminished. Diagnosis of true orbital aneurism, and ligation of common carotid advised, which was consented to by patient. The immediate effect of operation was cessation of the bruit and pulsation, and a diminution of the exophthalmus. On 14th day, pulsation returned, and tumor again began to grow. Three years later, eye enucleated and growth removed. On examination, it was found to consist of two portions: on its inner and upper side was a large mass of convoluted and sacculated vessels, held together by connective tissue and loosely connected to the more solid part of the tumor. This portion differed from the other in containing more connective tissue, but was in structure like a sponge, with cavities of irregular size which communicated freely with blood-vessels.

Optical Delusions in the Insane, Probably Caused in Some Cases by Disease of the Macula Lutea. Strawbridge.—*Amer. Jour. Med. Sciences*, Jan., 1877.

S. reports a case of optical phenomena, probably caused by retinitis maculæ, which were a source of great annoyance to the person, who regarded them as originating from a diseased mind. V.=$\frac{20}{70}$. Atrophic excavation in both discs, small arteries. Macula appears as an ellipsoid figure filled with distinct black dots, which in some places appeared to coalesce, forming small, black patches. This would readily account for the central scotoma. Both eyes presented about the same condition.

A Contribution to the Etiology of Optic-Nerve Atrophy. Bull.—*Amer. Jour. Med. Sciences*, April, 1877.

The author considers the effects of malarial poison upon the optic-nerve centres, and cites several cases. In the congestive types of malarial disease, the attack is usually ushered in by a dimness of V. which rapidly goes on to complete obscuration, the amblyopia being probably the result of increased intracranial pressure. A repeated number of such attacks may produce a permanent organic change in the fibres of the optic nerve or tract, or in the nuclei of origin, by long duration and repeated pressure. The more plausible view of the origin of the atrophy is that it starts from mal-nutrition and consequent death of the nuclei of origin.

New Modifications of the Ophthalmoscopic Mirror. Wadsworth and Loring.—*New York Medical Record*, Jan. 6th, 1877.

These are modifications of the mirror in Loring's ophthalmoscope. The mirror as modified by Wadsworth is circular, but only fifteen millimetres in diameter. This permits it to be inclined at an angle of 20°. The mirror rotates from right to left, so that either eye can be examined. Its disadvantage is that, on account of its size, sufficient light is not obtained from it for examination by the inverted method. Loring's later modification consists in cutting a vertical segment from the side of the original mirror. The mirror is then swung vertically on two pins, thus admitting of inclination. It gives abundant light for either method of examination. A still later modification consists in cutting off both sides of the original circular mirror, making a narrow parallelogram, 16 millimetres in width, instead of a circular mirror. It inclines in both directions, and can be used perfectly well for either method of examination. If more light is needed, a further modification consists in having a small central mirror swung on pivots, surrounded by a concentric stationary mirror.

A NEW INSTRUMENT FOR SECONDARY CATARACT OPERATIONS. STRAWBRIDGE.—*American Journal of Medical Sciences*, April, 1877.

The instrument consists of two needles, fitting closely on each other and having an outer cutting edge. The needles are 8 mm. long, and end in a handle of sufficient length to form a well-adjusted instrument. The handles are fastened together by a screw, the needles dovetail together 8 mm. from their points, and the effect of pressing their handles together, is to cause the needle points to spread up to 5 mm. The instrument is also provided with an adjusting screw to accurately approximate the needle points. In operating, they are passed through the cornea like a cataract needle, the false membrane is punctured, and then pressure on the handles separates the points and a free large opening is made. After the first cut, the instrument can be turned on its axis so as to make successive incisions in any desired direction.

When the membrane is very extensive and liable to give way before the cutting instrument, the addition of the scissors movement is desirable, the needles being given a double cutting edge. These instruments can also be used in the treatment of detached retina, by perforating the sclerotic.

DESCRIPTION OF A PARASITE, FILARIA LOA OR DRACUNCULUS LOA, REMOVED FROM THE CONJUNCTIVA OF A NATIVE OF GABOON, WEST AFRICA. By PROF. LEIDY.—*American Journal of Medical Sciences*, July, 1877.

The worm is 16 mm. long, cylindroid and tapering towards one end. The thicker end appears to be the head, as it is rounded and presents a prominent, papilliform, unarmed mouth. The narrow end terminates in a minute conical thickening of the integument. The thicker end measures 0.3 mm. in diameter ; the middle of the body 0.25 mm.; and the narrow end 0.175 mm. The integument is thin and very tough. Within this is a thick brown layer of longitudinal muscular fibres. The intestine appears to be straight, but no anal aperture could be found. About one millimetre from the thick end there is a slight prominence, from which striæ extend inwardly towards the intestine, and appear to indicate a lateral outlet. These worms appear not only in the conjunctiva and eyelids, but also in different parts of the body. The parasite is probably imbibed in the water used for drinking purposes. They are exceedingly common, but very difficult to seize and remove.

A CONTRIBUTION TO THE STUDY OF INHERITED SYPHILIS OF THE EYE. CHAS. S. BULL, M.D.—*American Journal of Medical Sciences*, July, 1877.

Bull calls attention to the importance of recognizing the great combining qualities, the miscibility of syphilis as a disease. Struma and tuberculosis are very frequent coexisting taints with the congenital syphilis, and their existence being once recognized, these diatheses should all be treated. Experience will lead us to modify the combined treatment as the various symptoms become more or less manifest. If a patient has marked evidence of struma in addition to syphilis, mercury must be prescribed with caution, and its use must never be continued for any great length of time. Where there is emaciation without interference with digestion, cod-liver oil without iron is indicated ; but when anæmia comes in, iron should be administered and the best form is the syrup of the iodide. If the secretions are disordered, the alkalies or the hypophosphites must be given with milk. If tuberculosis is present, bark and mineral acids are indicated. By attending to the treatment of these complications, we may materially shorten the duration of a parenchymatous keratitis, with or without iritis.

A FEW WORDS ON THE PURPLE OF THE RETINA. A. ALT.—*New York Medical Record*, August 4th, 1877.

Alt concludes, from his own investigations, that the purple of the retina is not produced by the pigmented epithelial layer, which idea was advanced by Kühne, for in experimenting on albinotic rabbits, he obtained the same results as in pigmented animals. Kühne has since drawn the same inference as Alt from the above facts.

A CASE OF RARE FRACTURE OF THE ORBIT, WITH DOUBLE RUPTURE OF THE CHOROID. C. S. BULL.—*New York Medical Record*, December 22d, 1877.

The cause of the injury was a blow from a heavy glass bottle. There was a long vertical fracture of the superior maxillary bone, reaching from the orbital margin nearly to the alveolar arch, with depression of the inner fragment about $\frac{1}{4}$ of an inch. After the swelling had subsided, the line of fracture could be traced backward through the orbital floor, as far as the finger could reach. One nasal bone was also broken. There was a crescentic rupture of the choroid on each side of the optic disc, but no injury to the lens, which was in place.

RETINITIS APOPLECTICA AND EMBOLIC INFLAMMATIONS OF THE RETINA. H. D. NOYES.—*American Journal of Medical Sciences*, October, 1877.

N. thinks that an explanation of the above lesions should be sought in the theory of minute and multiple embolisms of the retinal arteries, a view which has already been suggested by Leber. The experiments of Cohnheim upon the embolic process are considered. The infarction after embolism can only occur in tissues which contain terminal arterioles in Cohnheim's sense. N. thinks that the combined facts in this retinal disease of collapsed vessels and infarction can only be explained by embolism. If the plugs cannot always be demonstrated, it is because they are very small and are concealed by the infarction. The fact that the blindness resulting in these cases, though sudden, is often not at once complete is easily explained: by the first effect of embolism, the blood supply of the retina over the affected region is cut off, and the damage becomes more intense and extended as symptoms of infarction advance.

A CONTRIBUTION TO THE ANATOMY OF THE HUMAN RETINA. NORRIS AND SHAKESPEARE.—*American Journal of Medical Sciences*, October, 1877.

The eyes examined were opened by an equatorial section, and after removal of the vitreous, the retina *in situ* was exposed to the action of a ¼ per cent solution of silver nitrate.

On the internal surface of the retina, around the optic-nerve entrance and extending on all sides four or five papilla-diameters, appeared a single layer of flat epithelioid cells with granular protoplasm and large round or oval nuclei. Focussing deeper, there are seen more irregular spaces, some small, others large, in places resembling the arrangement of an endothelium with stomata, identical with the figures of Schultze, Retzius, and Schwalbe.

The nerve-fibre and ganglion-cell layers are well shown by this method. The nerve-cells are shown to gradually diminish as they descend the sides of the fovea centralis, until at the bottom there is only one layer. In the equatorial region these cells exist in a single layer and the interspaces are occupied by fine capillary vessels, lymph-channels, and by multitudes of exceedingly fine fibres, which are perhaps nerve-fibres.

EPITHELIOMA OF THE LACHRYMAL GLAND. LYMAN.—*Boston Medical and Surgical Journal*, October 18th, 1877.

Patient was a clergyman, æt. 30. Two years and a half previously he began to suffer from neuralgic pain in left temple and eyeball, and a few weeks afterwards slight protrusion of the globe was noticed. When he presented himself, the eyeball protruded half an inch from the orbit, vision was perfect, the pain slight. By the touch a tumor was detected in vicinity of lachrymal gland. An incision was made 1½ inches long, just below and parallel with the orbital margin, and the incision carried to the depth of an inch and a quarter into the orbit. Through this opening the entire growth was removed. There was very little hemorrhage, slight subsequent suppuration, and the wound was kept open for two weeks. The patient was discharged well in four weeks.

The tumor was one inch long by half an inch in breadth and thickness, of irregular shape and not very hard consistence. It proved to be an epithelial cancer, though the glandular structure was so completely involved as almost to prevent its recognition.

A CASE OF ANOPHTHALMUS. MURRELL.—*Phil. Medical and Surgical Reporter*, November 3d, 1877.

Patient was the fourth child of apparently healthy parents. Two of the three previous children are healthy, the third was lost by craniotomy during confinement. This child was born at full term, and is well developed in every respect, with the exception that both eyeballs are completely absent. The supraorbital and infraorbital ridges approximate nearer than normal, lessening the anterior opening of the orbits. All of the appendages of the eye are normal, except that there is anchyloblepharon of the outer third of each palpebral fissure. The orbits are absolutely empty, there being not even a rudimentary eye present.

A CONTRIBUTION TO THE STUDY OF SUBCONJUNCTIVAL SEROUS CYSTS. By CHARLES S. BULL, M.D.—*American Journal of Medical Sciences*, January, 1878.

The author calls attention to certain forms of cystic tumors, occurring beneath the conjunctiva, chiefly of the eyeball, but also of the eyelids, which, occupying comparatively little room in the cavity of the orbit, may be distinguished from the larger class of orbital cysts. These subconjunctival cysts are always simple or barren, that is, they contain fluid, or unorganized matter. They seem always to be formed by the enlargement and union of the spaces in fibro-cellular and areolar tissues. As the fluid in such a tumor collects and increases and the cavity enlarges, the wall of partition between a number of such spaces breaks down, until finally we have one large cavity. If the pressure of fluid continues, the cavity gains a perfect wall or lining, from a pressing together and union of a number of connective-tissue trabeculæ. This, however, does not always occur. The causation is but little understood, though some are really congenital. They occur most often in children and young adults, and are met with either at the internal or external angle of the eyelids, more often at the latter. More rarely they are situated immediately in front of the lachrymal sac, along the inner angle of the eyelids and side of the nose. Bull cites five cases, two of serous cysts near the external canthus, one of subconjunctival prelachrymal cyst with glairy contents, and two of cysts of the caruncle with clear serous contents. These latter are very rare. All five cases were cured by dissecting out and removing the cyst-wall, either entire or in part.

THE DISTRIBUTION OF NERVES IN THE IRIS. By HENRY F. FORMAD, M.D.—*American Journal of Medical Sciences*, January, 1878.

The author considers the descriptions of these nerves given by Kölliker and Rüdinger as incorrect. The nerves do not lie all in one plane ; most of the larger nerve-trunks lie in front of the blood-vessels, running parallel with, but at some distance from them. Formad considers the iris divided in its breadth into four equal zones. In the first or outer zone, and very near the ciliary border, the nerves coming from the ciliary muscle form an irregular, dense, circular plexus of large nerve-trunks, which goes round the entire circumference of the iris. A second circular plexus, which forms more arches, runs through the second zone. A third circular plexus, like the foregoing, but more irregular, runs through the third zone. In the fourth zone which includes the sphincter, run a fourth and a fifth circular plexus, composed of thinner nerve-trunks, the fifth running very near the pupillary border. These plexuses are connected with one another by transverse or radiating nerve-trunks of moderate size. Most of the radiating trunks originate in the first circular plexus, and go directly to the second; others run in an isolated course, crossing the second and third plexus, dividing or uniting with some other nerve-trunk, then form an arch or a loop, and finally join one of the plexuses. The larger nerve-trunks are chiefly made up of medullated nerve-fibres with distinct neurilemma and prominent nuclei. From all large nerve-trunks which form the circular plexuses, and from the loops formed by the radiating trunks, smaller nerve-trunks of a mixed elementary character take their departure, which in a similar way unite to form plexuses; from these still smaller nerve-twigs arise, which inosculate with one another, and finally dividing into their primitive fibrils, form a terminal network all over the iris. Formad could never find any ganglion-cells in the iris. No description of the first or outer plexus of nerve-fibres has heretofore been published.

A CONTRIBUTION TO SYPHILIS OF THE EYELIDS. C. S. BULL.—*New York Medical Journal*, March, 1878.

Bull reports four cases of syphilitic infiltration and ulceration of the eyelids, involving both the cutaneous and mucous surfaces, which originally were localized deposits, as in the tubercular syphilides.

ESERINE AND PILOCARPINE IN THE TREATMENT OF EYE DISEASES. WILLIAMS.—*Boston Medical and Surgical Journal*, March 14th, 1878.

W. has made extensive use of eserine in the treatment of corneal ulcers, thinking that its strong contractile action on the pupil, limiting very much the amount of light which would reach the retina, might lessen the reflex action causing these spasmodic contractions and thus prove of advantage. He uses it in the strumous corneal ulcerations of children, in herpetic or phlyctænular eruptions of the conjunctiva or cornea, in traumatic or gonorrhœal ulceration, and in ulcus serpens, with great advantage. The supraorbital pain, so common in these affections, is relieved in a marked degree by the eserine, and the ulceration has assumed a healthier aspect.

In experiments made with chlor-hydrate of pilocarpine, there was less conjunctival injection, less supraorbital pain, and less spasm of the muscle of accommodation than when eserine was used, but the drug was equally efficacious.

OPHTHALMOLOGICAL REVIEW.

By DR. E. GRUENING.

1. Goldzieher, Dr. W. Zur Histologie des Pterygiums. (Contribution to the Histology of Pterygium.) *Centralbl. f. Prakt. Augenhlkde.*, Hirschberg, January, 1878.

2. Hensen, V., and Voelkers, C. Ueber den Ursprung der Accommodationsnerven, nebst Bemerkungen über die Function der Wurzeln des Nervus Oculomotorius. (On the Origin of the Nerves of Accommodation, with Remarks on the Function of the Roots of the Oculomotory Nerve.) Graefe's *Arch. f. Ophth.*, Vol. XXIV., p. 1.

3. Adamuek, Prof. E. Zur Therapie der Episcleritis. (Contribution to the Treatment of Episcleritis.) *Centralbl. f. prakt. Augenhlkde.*, Hirschberg, September, 1878.

4. Michel, Prof. C. Die Spontane Thrombose der Vena Centralis des Opticus. (On Spontaneous Thrombosis of the Central Vein of the Optic Nerve.) Graefe's *Arch. f. Ophth.*, Vol. XXIV., p. 2.

5. Hutchinson, Jonathan. On Retinitis Hæmorrhagica and its Suggested Connection with Gout and Venous Thrombosis. *Medical Times and Gazette*, London, April 13th, 1878.

6. McHardy, McDonald. On the Application of Magnets for the Removal or Displacement of Iron or Steel Chips from within the Eye. *Medical Times and Gazette*, London, April 13th, 1878.

7. Hutchinson, Jonathan. Clinical Groups of Cases of Amaurosis. *London Ophthalmic Hospital Reports*, December, 1877, p. 111.

8. Schroeter, Dr. Paul. Spontan entstandene Seröse Iriscysten. (On Iris-cysts of Spontaneous Origin.) *Klin. Monatsbl.*, Decbr., 1877.

9. Michel, Prof. I. Ueber eine orthopädische Behandlung von Augenmuskel-Lähmungen. (On the Orthopædic Treatment of Paralysis of the Ocular Muscles.) Zehender's *Kl. Monatsbl. f. Augenhlkde.*, November, 1877.

10. Martin, G. Sur les Causes ordinaires d'Insuccès dans l'Extraction de la Cataracte de Morgagni (Cataracte à noyau flottant) et sur les Moyens d'en triompher. *Annales d'Oculistique*, Janvrier–Février, 1878.

11. Just, Dr. Drainage des Auges mit unglücklichem Ausgang. (Drainage of the Eye followed by an unfavorable Result.) *Kl. Monatsbl. f. Augenhlkde.*, October, 1877.

1. Goldzieher had the rare opportunity of examining a pterygium connected with the eyeball. From his microscopical sections, he draws the following conclusions as to the genesis of pterygia in general. The process commences with a loss of substance of the cornea, and a swelling of the conjunctiva at the limbus. The projecting conjunctival edge unites with the cornea and forms a slit-like cavity lined with epithelium. As the process continues, the upper conjunctival layer is drawn towards the centre of the cornea, while the conjunctiva itself becomes folded by the constant traction. Finally the corneal ulcer cicatrizes, the loss of substance being replaced by transparent tissue, resembling the cornea in all respects. The greater part of the pterygium may be considered a duplicature of the conjunctiva, while the apex consists of one layer of conjunctiva only.

2. In their researches these gentlemen employed the method of removing the great hemispheres of the animals experimented upon (dogs), thus rendering the nerves at the base of the brain accessible. First of all, they were able to corroborate *the view* held by others that the nerves of accommodation run their course in the trunk of the oculo-motory nerve. In their search for the central origin of the oculomotory nerve, Völckers and Hensen made use of induced currents, and having electrically examined the floor of the third ventricle, found the centre of accommodation at a point where the third ventricle slopes into the posterior wall of the infundibulum. In a region situated a little farther backwards, they discovered the centre for the sphincter of the iris; at the entrance of the aquæductus Sylvii, the centre for the rectus internus, and posteriorly to this last centre the distinct and isolated centres, 1st, for the rectus superior; 2d, the levator palpebræ superioris; 3d, the rectus inferior; and 4th, the obliquus inferior.

3. The oculist knows that episcleritis is a disease of long duration. Every effort made to shorten the course of this frequent disease deserves the attention of the practitioner. Episcleritis manifests itself by a more or less circumscribed inflammatory scleral swelling, presenting a violet coloration. When the inflamed spot is pressed, it becomes immediately pale and the swelling diminishes; with the release of pressure, the former condition of swelling and discoloration returns. These changes

produced by pressure must necessarily lead to the conclusion that, in the process of episcleritis, we have to deal principally with a turgid and dilated condition of the scleral vessels. From this follows that a diminution of the hyperæmia may favorably influence the course of the disease. Guided by these considerations, Adamük incised the inflamed scleral patches, and found that this procedure shortened materially the duration of the disease. In twenty cases thus treated, the results are highly gratifying; the episcleritis being invariably cured after three or four days.

4. Apoplexy of the retina is a symptom, of the local cause of which we know very little. In seven cases of a characteristic form of retinal apoplexy or retinitis hæmorrhagica, Michel diagnosticated, "thrombosis of the central vein of the optic nerve," and in one of these cases the presence of a thrombus was demonstrated at the post-morten examination.

5. At the meeting of the Clinical Society of London, March 22d, 1878, Mr. Jonathan Hutchinson read a paper on Retinitis Hæmorrhagica and its suggested Connection with Gout and Venous Thrombosis. He exhibited three ophthalmoscopic drawings to illustrate the malady, and remarked that they presented innumerable hemorrhages scattered over all parts of the fundus and all of flame-shape, and radiating from the disc. He showed the extreme turgescence of the vena centralis, the diminished calibre of the artery, and the considerable swelling of the disc and the adjacent parts. The extreme turgescence of the vein led him to conjecture that the cause of the disease might not improbably be plugging of the central vein. This hypothesis would account for the sudden onset, the frequency with which one eye was affected, and the extreme multiplicity of the hemorrhages. He had tried in several cases, since this idea had occurred to him, whether stagnation of the blood in the veins could be proved by pressure on the eyeball, and although in most cases it was certain that the veins did empty somewhat on pressure, yet more than once they had appeared to be almost motionless. He had not had any opportunity for making a dissection. His hypothesis was, that, in connection with gouty tendencies, the vein became plugged, and that from this plugging all the other conditions resulted.

6. In the Clinical Society of London, Mr. McDonald McHardy read notes of a case illustrative of the application of magnets for the

removal or displacement of iron or steel chips from within the eye. The patient had sustained an injury of the left eye, caused by chips of steel flying from a tool that he had been striking. The fragment of metal was found upon the anterior surface of the lens, occupying a situation downwards and inwards from its centre, and so placed as to be concealed, except when the pupil was widely dilated. Seventy-two hours after the accident, a powerful electro-bar magnet was held before the patient's eye, and when the pole was four inches from the cornea, the chip was seen to spring away from the lens to the inner surface of the cornea. On withdrawal of the magnet, the chip fell into the anterior chamber, whence it was evacuated through an ordinary incision.

7. Hutchinson puts together a number of cases of amaurosis (the term embraces cases of atrophy of the optic nerves from all causes, as well as cases of blindness without visible change), and attempts to subdivide them into classes, in accordance with their leading clinical features. Of the first group, constituting Optic Neuritis from Tumor in the Brain, there are six cases mentioned. In three an autopsy was made. Intense headache, neuritis with choked disc, and subsequently atrophy, absolute blindness and dilated pupils, convulsions, frequently paralysis of the orbital nerves, or some degree of hemiplegia, are the principal symptoms which occur in amaurosis from cerebral tumor. This condition is differentiated from tubercular meningitis by the circumstance that the symptoms develop more gradually, are attended by far less constitutional disturbance, and are more protracted. The fact that no benefit accrues from treatment distinguishes this class of cases from cases of syphilitic gummata. The second group, Amaurosis from Optic Neuritis in the Tertiary Stage of Syphilis, comprises twenty-one cases. Cerebral syphilis may be divided into five classes. 1st, cases in which disease of the coats of the arteries leads to thrombosis or hemorrhage; 2d, those in which gummata of the meninges are present; 3d, those in which disease of the bone exists; 4th, those in which the changes implicate nerve-centres, but are attended rather by degeneration than growth, and lastly, perhaps, a group in which a travelling form of primary neuritis is present.

Of these five groups, it is probable that the second supplies us with by far the larger number of amaurosis cases. The third group comprises cases of neuritis with cerebral illness in children, ending in perfect recovery of health. Tubercular meningitis is a common cause of optic neuritis, but the cases usually end fatally, and do not proceed to that stage to which the term amaurosis is applicable. In a certain number, however, after a severe attack of cerebral disease, the child recovers and is found to be blind. It is of such cases that the group is composed. The precise nature of the primary lesion must be left in doubt. It is possible that in some of the cases the disease may have been of the nature of cerebro-spinal meningitis, and in others it is probable that the head-symptoms were in association with one or other of the exanthemata.

8. Schröter reports a case of iris-cyst of spontaneous origin. The patient, a girl, aged 18 years, had noticed the altered appearance of the eye only a few days before she presented herself. She had never sustained any injury of the eye, nor suffered from inflammation of the organ. The cyst occupied the temporal portion of the iris, extended from its ciliary insertion to a point near the pupillary margin, projected into the anterior chamber, and lay in contact with the posterior surface of the cornea. Vision normal. The operation for the removal of the cyst was performed with a lance-shaped knife, in the manner recommended by Arlt. The anterior cyst-wall was punctured. The cyst then collapsed, was seized with forceps, drawn out in toto and removed with scissors. The microscopical examination showed exactly the same conditions found in cysts of traumatic origin.

9. The galvanic treatment of paralysis of the ocular muscles is frequently unsatisfactory; it lasts a long time, often many months, and, in some cases, does not counteract the permanent contraction of the antagonist. Michel recommends a new and simple method of treatment, founded on the principle of passive movement. He seizes the conjunctiva over the insertion of the paralyzed muscle with an ordinary fixation forceps, rotates the globe in the direction of the sphere of muscular action, even beyond the limit of contraction, then carries it back and continues these movements to and fro about two minutes. The immediate effect of this manipulation is very striking, the increase in contractile power amounting at least to 1½ mm. One hour later, the favorable effect, though somewhat diminished, still averages a prism of 12° to 16°. The re-establishment of the complete field of fixation is brought about gradually. The pain connected with the procedure is trifling ; the slight conjunctival irritation is readily removed by the application of cold compresses. Michel claims the following advan-

tages for this method of treatment: 1st, elimination of the action of the antagonist; 2d, shortening of the duration of treatment.

10. Martin thinks that the difficulties which present themselves at times in the delivery of the nucleus of a Morgagnian cataract are due to the fact that the capsular wounds are generally made too small. In order to secure against the retention of the nucleus and effect its easy passage in every case of Morgagnian cataract, he recommends the following operative steps:

a. Corneal section, Lebrun's upper median flaps.

b. Iridectomy, if required.

c. Extensive horizontal division of the capsule in the largest diameter of the lens, with v. Graefe's cystotome.

d. Expulsion of the contents of the capsular sac by depression of the upper lip of the corneal wound, in the manner practised by Weber.

M. lays particular stress upon the correct execution of the third step, *i. e.*, extensive horizontal division of the capsule in the largest diameter of the lens.

11. Drainage of the eye by means of a loop of gold wire is not as harmless an operation as we were led to think from the publications of v. Wecker. In a case of recent detachment of the retina in a myopic eye, Just placed the wire seton through the eye in accordance with v. Wecker's directions. (The instruments used were furnished by Lüer of Paris.) In the evening of that day, the eyeball became painful, the conjunctiva chemotic, the upper lid swollen. The patient passed a sleepless night, and in the morning the eye presented all the characteristic symptoms of suppurative choroiditis. The gold wire was removed with great difficulty from the chemotic ocular conjunctiva. The patient, a woman, was discharged on the third day at her urgent request, but the inauspicious yellow reflex from the background of the eye foretold the coming event.

OTOLOGICAL PART.

THE USE OF THE MEMBRANA TYMPANI AS A PHONAUTOGRAPH AND LOGOGRAPH.

By CLARENCE J. BLAKE, M.D., Boston.

Continued from Archives of Ophthalmology and Otology, Vol. V., No. 1, 1876.

At the time of the publication of the first paper on this subject, which appeared in these Archives in 1876, it was intended to continue the work in a series of communications, which should give the results of further experiments in relation to the system of "Visible Speech," originally devised for the instruction of deaf-mutes by Prof. A. Melville Bell. Various circumstances, among them a participation in the interesting telephonic researches of Prof. A. Graham Bell, prevented the carrying out of this intention. Since the publication of the first paper mentioned, great advances have been made in the graphic study of sonorous vibrations, and especially in the study of the recorded vibrations produced by the human voice. The phonograph of Edison especially has given an impetus to study in this direction which is showing itself in such elaborate observations as those of Prof. Fleeming Jenkin and Mr. Ewing of London,* and of Prof. A. M. Mayer, of the Stevens Institute, Hoboken.†

Since the publication of the first paper in these Archives also, the membrana tympani phonautograph has acquired a certain interest, since it was the use of the instrument there described, in experiments in conjunction with the author, which gave Prof. Bell the clue to the telephone as exhibited in his first membrane telephone at the International Exhibition in 1876.‡

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* Nature. The Phonograph and Vowel Sounds, July and Aug., 1878.

† Sound. A. M. Mayer, Ph.D. New York, Appleton & Co., 1878.

‡ The Telephone. Prof. A. Graham Bell. Journal of the Society of Arts, Nov. 30th, 1877.

Of the three objections which have been made to the use of the human membrana tympani for the purpose of making phonautograms, one has considerable weight, and another has been disproved by the lapse of time since the first instrument was constructed.

The first is, the difficulty of procuring the proper material.

The second is, that the friction resulting from the use of a smoked surface of glass, mica, or collodion film with so light a stylus as that required in using so delicate a vibrating membrane, materially affects the resultant tracing and gives a less accurate representation of the vibrations of the membrane than can be obtained in other ways. In a paper on the photographic reproduction of sonorous vibrations, Prof. E. W. Blake, Jr., mentions the measurement of some of the tracings made from the membrana tympani on smoked glass, and shows that the number of recorded vibrations falls considerably below the ordinary pitch of the voice, being in some cases as low as eighty per second.*

The third objection is, that the membrana tympani and the ligaments of the ossicles become in time so changed by exposure as to be useless for phonautographic purposes. This objection is answered by the fact that the instrument first described by me is still in use with the same membrana tympani, and the tracings which it now gives bear favorable comparison with those first made.

A review of the history of the phonautograph in its various forms shows that the transcription of the vibrations of the membrana tympani and ossicles was first suggested by Prof. Adam Politzer, who published, in 1864, a series of interesting experiments upon the graphic method of illustrating such vibrations.† The object of these experiments was to study and to illustrate the vibrations of the membrana tympani and ossicles in the healthy subject, to determine the effect of the contraction of the musculus tensor tympani upon such vibration, and also to determine comparatively the effect of varying atmospheric pressure.

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* A Method of Recording Articulate Vibrations by Means of Photography. E. W. Blake, Jr., Hazard Professor of Physics, Brown University. American Journal of Science and Arts, July, 1878.

† Untersuchungen über Schallleitung und Schallfortpflanzung. Prof. Adam Politzer. Archiv für Ohrenheilkunde, Band I., s. 59.

The means employed for the accomplishment of this purpose were suggested by the previous experiments of Savart, and were carried out with the assistance of König, who placed the then new phonautograph of Leon Scott at the service of the investigator.* The application of these means by Prof. Politzer was, however, both original and ingenious, and constitutes the first record of the phonautographic use of the membrana tympani. The preparations used in these experiments were from the human subject and from birds, the latter being chosen for study of vibrations of the membrane of the oval window, on account of the greater comparative excursions of the columella, and because of the difficulty of attaching the stylus to the base of the human stapes without seriously impairing the function of its membrane.

In the same volume of the Archiv für Ohrenheilkunde, Lucae makes use of the method suggested by Politzer, in his experiments upon sound conduction through the bones of the head, a stylus being attached to one of the ossicula, as in Politzer's experiment, and a vibrating tuning-fork being inserted in the external auditory canal.†

Both of these series of experiments conducted upon the graphic method were physiological in character, being undertaken with the view rather of studying the functions of the sound-transmitting portions of the organ of hearing than of using these structures as a substitute for the apparatus of Scott in the study of aerial vibrations produced by movement of various bodies, or by the human voice.

In the first volume of his recent text-book, Prof. Politzer again refers to his previous experiments and to the great adaptability of the membrana tympani to the reception and transmission of a wide range of musical tones, as compared with any artificial membrane having a plane surface.

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* Archiv für Ohrenheilkunde, Band I., s. 61.

† Untersuchungen über die sogenannte "Knochenleitung," etc., August Lucae, Archiv für Ohrenheilkunde, Band I., s. 303.

"If an artificial membrane stretched over a ring is struck, it gives forth a tone which varies according to the degree of tension of the membrane, and which is its individual tone. Such a membrane vibrates most readily in reponse to a tone corresponding to its individual tone; its vibrations are, however, considerable in response to tones which approximate its individual tone, and less and less in response to tones receding in the musical scale from its individual tone. The membrana tympani, however, possesses the peculiar property of transmitting tones of various pitches, not only in succession, but simultaneously and to our perception in an equal degree. It should on no account be classed as an elastic membrane, the membrana tympani is rather, from the anatomical arrangement of its fibres, a stiff and but slightly elastic membrane and this property is of importance, inasmuch as it prevents consequent vibrations which would interfere with the proper perception of the tone."*

That the use of the human membrana tympani, in conducting physical investigations in this direction, as a substitute for an artificial membrane possesses certain advantages is, therefore, self-evident, provided always that the delicacy of the mechanism employed in making the record corresponds as nearly as possible to that of the human instrument. The first series of the accompanying illustrations represents tracings made upon smoked glass by a stylus attached to the malleus and to the incus in the direction of the long axis of the manubrium and of the long process respectively, in reponse to vowel sounds sung into the mouthpiece of the instrument at various pitches, the recording plate moving at a uniform rate. While these curves correspond very fairly in their general characteristics to those made by the phonautograph of Marey, they differ greatly from curves of corresponding tones obtained by the photographic process, as illustrated in the paper by Prof. E. W. Blake already cited; indeed the effect of the increased friction resulting from an increase of speed in the movement of the smoked glass plate was plainly shown in these phonautographic experiments by a greater alteration in the resultant curve than would have resulted from an increase of speed in the movement of the plate alone.

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* Lehrbuch der Ohrenheilkunde. Prof. Adam Politzer, 1878. Schallfortpflanzung durch Trommelfell und Gehörknöchelchen, Band I., s. 67.

The construction of the ingenious instrument of Mr. Barlow, and the account of his experiments in a paper read before the Royal Society,* demonstrating the varying pneumatic pressure accompanying the production of consonant sounds, has opened a new and very interesting field for investigation, and in connection with the general introduction of the telephone, suggested investigations as to the influence which this varying pneumatic pressure might have upon the movement of a metal disc or membrane vibrating in response to the combined vowel sound† in which the human membrana tympani was used as a logograph, the logographic curves produced by the various consonant sounds corresponding very fairly to the measurements of the deviations of a Thompson short-coil reflecting galvanometer, in response to the current induced in a Bell telephone by the same consonant sounds. An attempt was made to show the effect of the pneumatic pressure upon the coincident vibration of the membrane as is shown in the second series of plates herewith presented, by obtaining first a measure of the excursion of the membrane in response to a consonant sound, the glass plate being at rest; second, a logographic curve made with the plate moving at the rate of five millimetres in the second, and finally a third, phonauto-logographic tracing made with the plate moving at the rate of five centimetres in the second, representing the excursion consequent upon the pneumatic pressure with the vibrations resulting from the combined vowel sound.

As the pneumatic pressure, and consequently the tension of the membrane, varies considerably during the production of the consonant sound, a corresponding influence upon the vibration of the membrane is exerted, as is shown in the original tracings when examined under the microscope.

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* W. H. Barlow, F.R.S., "The Logograph," reprinted in the Popular Science Review, London, July, 1874.

† Phenomena of Audition and the Telephone. C. J. Blake. British Society of Telegraph Engineers, London, May 8th, 1878.

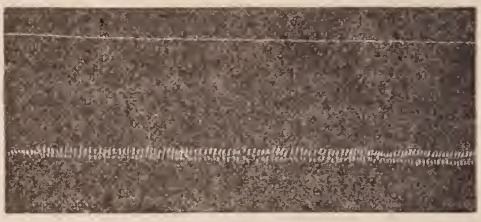

FIG. 1.

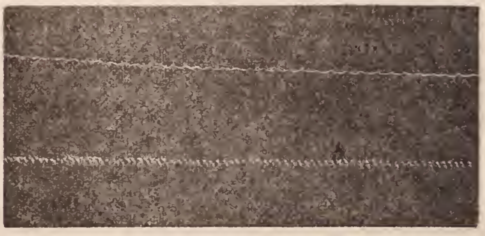

FIG. 2.

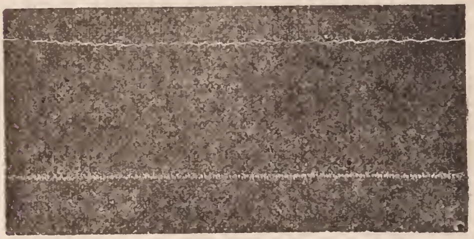

FIG. 3.

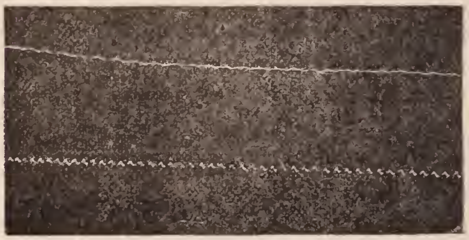

FIG. 4.

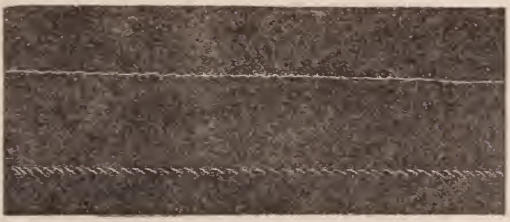

FIG. 5.

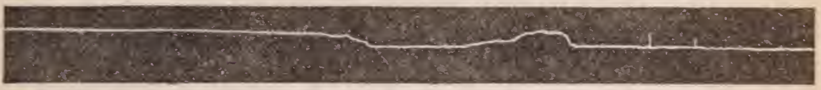

FIG. 6.

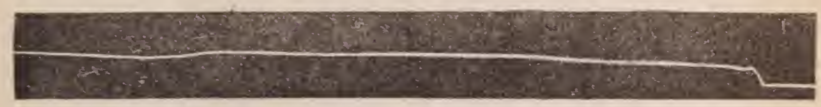

FIG. 7.

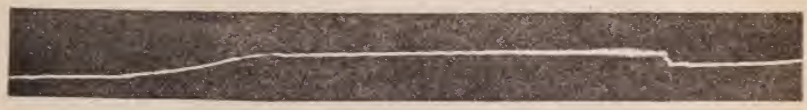

FIG. 8.

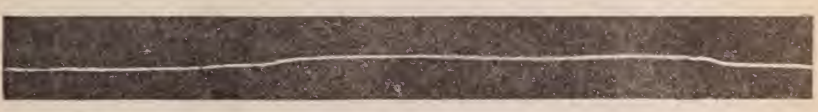

FIG. 9.

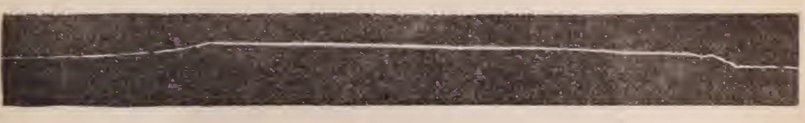

FIG. 10.

NOTE IN EXPLANATION OF THE DRAWINGS.

FIG. 1. Vowel sound A,* 896 v. s. and octave.
FIG. 2. Vowel sound E, 1,792 v. s. and octave.

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* Pronounced according to the German language, not the English.

FIG. 3. Vowel sound I, 2,304 v. s. and octave.

FIG. 4. Vowel sound O, 448 v. s. and octave.

FIG. 5. Vowel sound U, 1,632 v. s. and octave.

FIG. 6 illustrates the measurement of the excursion of the membrana tympani under the pneumatic pressure occurring in the production of the consonant sound B, and also the logographic curve of B, with a portion of the phonauto-logographic curve of B.

FIG. 7 represents the phonauto-logographic curve of B.

FIG. 8, the phonauto-logographic curve of D.

FIG. 9, the phonauto-logographic curve of F.

FIG. 10, the phonauto-logographic curve of K.

In Figs. 1, 2, 3, 4, and 5, the upper line represents the sound curve, drawn by the stylus attached to the malleus, of the vowel sound at the pitch indicated, the lower line being the same vowel sound one octave higher, the tracings representing very fairly the increase in intensity of the tone with the rise in pitch. This is more marked with the vowel sound A, and the lower line in this plate (Fig. 1), when examined under the microscope, shows tracings between the dots represented which suggest the curves obtained by the photographic process mentioned. In Figs. 7, 8, 9, and 10, the tension of the membrane under the pneumatic pressure of the consonant sound so far limited the excursion of the membrane in vibration as to render it necessary to enlarge the tracing four diameters before reproduction by engraving.

CONTRIBUTIONS TO THE PATHOLOGY AND PATHOLOGICAL ANATOMY OF THE ORGAN OF HEARING.

By Dr. S. MOOS.

(*Second Paper.**)

Translated by Swan M. Burnett, Washington, D. C.

A.

FOUR CASES OF PHLEBITIS AND THROMBOSIS OF THE LATERAL SINUS FROM OTITIS, WITH A FATAL TERMINATION.

Case I.—Purulent inflammation in the right ear with deafness in a young man of 20 years of age.

Otitis media purulenta dextra, with central perforation of the membrana tympani. Retention of the pus in the middle ear in consequence of complete closure of the perforation by a long-stemmed polypus and the handle of the malleus, which was detached from the membrana tympani and united with the polyp. Inspissation of the purulent matter in the middle ear and the mastoid cells. Phlebitis and thrombosis of the sinus transversus dexter and the vena emissaria Santoriniana, as well as of the jug. int. dext. Metastatic infarctions of the lungs. Fibro-purulent sacculated pleuritis and pneumonia on the right side.

John Woehrle, 30 years of age, a servant, from Hilsbach, was brought on the 3d of October to the clinic of Prof. Friedreich.

History of the case.—The patient states that in his twentieth year he suffered from a *purulent discharge* from the *right* ear, attended with *impairment of hearing*. In the course of six months the discharge ceased ; a slight diminution of hearing power remaining. Within the last two weeks the purulent discharge has again made its appearance on the *right side*, together with a continuous violent pain in the right ear and head, which has deprived the patient of sleep. Within the last week the intensity of the pain has diminished, to be followed by frequent slight chills, loss of appetite, constipated bowels, debility, and slight cough.

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* Vide : Archives of Oph. and Otology, Vol. III., No. 2, p. 173.

Status præsens.—The patient is much debilitated and pale; mind not perfectly clear; complains of headache in the forehead and right temporal region. An accurate examination of the function of hearing showed that the hearing power on both sides was very much diminished. The watch was not heard on the *right side* at all, neither on contact nor from bone conduction. On the *left side* it was heard at about 2″. He is not certain whether the hearing power has diminished, as compared with its former acuteness, within the last two weeks.

The chest and abdominal organs presented nothing abnormal. No abdominal sensitiveness, no splenic enlargement.

Temperature on October 3d and 4th:—6 P.M., 39.6, pulse 96; 8 P.M. 41.4, chill, with grinding of teeth; 2 A.M., 39.2.

Clinical diagnosis.—Otitis media purulenta dextra cum perforatione membranæ tympani. Phlebitis sinus lateralis et meningitis cerebralis.

Ordered: Ice bladder to the head. Calomel.

Temperature on October 4th:—8 A.M., 39.2; 10 A.M., 40.8 (chill); 2 P.M., 38.6; 6 P.M., 39.6.

The patient grows somnolent. It is only with the greatest effort that he can take a few steps, and then with great uncertainty and danger of falling. He has, in addition, photophobia and impaired vision.

The otoscope shows the right external ear to be filled with thick pus, red and swollen. Only a portion of the membrana tympani is visible. Membrana tympani seems to be perforated.

After the cold applications, the patient feels somewhat better. The mind clearer. He complains of pain in the left upper arm. The movements of the extremities are slow and tremulous; no marked appearances of paralysis. Pupil and movements of the eyes normal. The tongue protruded straight.

There was no redness nor œdema, either in the region of the ear, the face, or neck.

Temperature, October 4th and 5th:—10 P.M., 40.6 (chill); 2 A.M. 39.0; 6 A.M., 38.8.

During the night of October 4th and 5th, jactitation, slight delirium.

Spleen somewhat enlarged. Percussion over the lungs negative. Auscultation: signs of a moderate bronchial catarrh.

During the next night, and on the following day, the chills were frequently repeated; the temperature did not fall below 39.8°, but on the 8th of October, it rose suddenly to 41.4, then fell to 36.6; at the end, it was 38.8.

The bronchial catarrh increased rapidly. Expectoration was difficult. On the evening of the 6th of October, the lungs showed the symptoms of consolidation, which continued until death.

The respirations were more frequent, as was also the pulse, which was at the same time dicrotic.

The energy of the heart's action diminished more and more. Since the 6th of October, he has taken Stocke's cognac mixture, and since the 8th, musk. In addition, a stronger abstraction of heat by means of a water cushion of 12° R., and further cold applications.

The condition became worse and worse, the tongue was perfectly dry and cracked. The urine (no albumen) was retained. One time he raised bloody sputa. At last the expectoration ceased entirely, and with the increasing prostration, in a condition of stupor, the patient died on the morning of the 10th of October, 1874, at 9½ o'clock.

Autopsy, 10th of October, 4 P.M. I pass over that part of the record which is not essential to an explanation of the case, and extract the following:

In the vena jugularis interna, fresh dark-red blood-clots, on the upper surface of which puriform softened detritus. In the cerebral sinuses, fresh dark-red coagula. In the right lateral sinus, puriform softened thrombi.

Anatomical diagnosis.—Thrombosis of sin. later. dext. and ven. jug. int. dext.

Metastatic infarction of the lungs. Fibro-purulent sacculated right pleuritis. Pneumonia dextra. Hyperæmia of the abdominal organs. Enlargement of the liver and kidneys. Acute splenic enlargement.

Examination of the right petrous bone:* The external meatus contained some pus. Its cutaneous covering is thickened. The dura mater covering the roof of the antrum, which appears bluish-red and tolerably soft, is in some places intimately connected with the bone by means of connective-tissue fibres, which come partly from the cavity of the drum through the fissura petro-squamosa. Its slightly red inner surface is thickened by deposits of connective tissue. Besides the alterations in the vena jugularis and sinus lateralis mentioned above, there are signs of phlebitis and thrombosis in the vena emissaria Santoriniana. The other sinuses are free.

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* I made no examination of the patient during life.

A further examination of the temporal bone gave the following: Much inspissated secretion in the external auditory canal. A large central perforation in the membrana tympani. From the middle of the upper edge of the perforation there sprang the very thin pedicle, about four lines long, of a polypus, whose head completely closed the perforation. To this the handle of the malleus, loosened from the membrana tympani and lying in the drum cavity, is lightly attached, but in such a manner that the whole formed a continuous mass. The whole middle ear is completely filled with a secretion for the most part inspissated. The incus is wanting.

The genesis of this case is very clear. The life of the patient hung, at a certain period, upon a thread. If any one, to change the metaphor, had cut this thread, the thin pedicle of the polypus, the thickened mass in the middle ear would have escaped. Since, however, this did not occur, it was natural that the inflammatory process, through the constantly increasing accumulation of the secretion, should finally pass to the tissues inside the cranial cavity, in this instance the sinus lateralis, and bring the life of the patient to an end. The stoppage of the discharge from the ear, to which the patient referred, was only apparent.

The marked fluctuations in temperature, at the time when the broken-down thrombi entered the circulation, is worthy of notice. This has also been noticed by Wreden, Schwartze, and others. In our case it amounted in one day, October 8th, to as much as five degrees (Celsius).

CASE II.—*Chronic purulent inflammation of the right tympanic cavity. Loss of the greater part of the membrana tympani; necrosis of the handle of the malleus. Loss of the incus. Corrosion of the canalis facialis. Phlebitis and thrombosis of the sinus transversus. Circumscribed purulent pachy- and leptomeningitis.*

Franz Kaiser, aged 10 years, was brought, on the 9th Oct., 1873, to the Heidelberg Children's Hospital, two hours before his death. His attendants could no longer bear his terrible outcries. For several days he had screamed continually, day and night, with insupportable pain in the right side of the head. The outcries were still continued in the hospital, in which he remained until he died. He retained consciousness until immediately before death. For a year he had complained of a discharge from the right ear, and sometimes of a slight headache.

Sectio cadaveris.—Slight rigor mortis, skin yellowish white, subcutaneous adipose tissue sparse, muscular tissue dark-red and well developed.

Skull-cap congested. Fresh blood-clot in the sinus longitudinalis. All the sinuses full of blood. Pia mater of the convexity slightly opaque. On the upper surface of the right half of the cerebellum, as well as on the cerebral fissure, the pia mater is infiltrated with pus, as was also the inner surface of the dura mater in the neighborhood of the sinus transversus dexter. The posterior surface of the right temporal bone is covered with a discolored mass of pus, which follows the connective-tissue processes of the dura mater into the temporal bone, and especially into the aquæductus vestibuli.

The surface of the bone, especially the portion corresponding to the flexura sigmoidea of the sinus transversus, is of a grayish color and uneven.

The convolutions of the cerebrum are moderately flattened, and its substance contains a medium quantity of blood. In the ventricles a somewhat increased quantity of opaque fluid. I pass over the remaining details of the section as unessential.

Anatomical diagnosis.—Chronic inflammation of the middle ear, purulent infiltration of the dura mater, thrombosis of the flexura sigmoidea of the sinus transversus. Circumscribed purulent leptomeningitis.

Section of the petrous bone.—Alcoholic preparation without the tube. The surface of the bone, especially that of the base of the temporal bone, of a bluish-red appearance. External meatus filled with pus and epithelium. Cutis thickened and easily detached from the bone. Of the membrana tympani only the spherical segment of the upper half remained, and this, with the short, necrosed and shortened lower end of the handle, was drawn inward. Incus wanting. Stapes in place and movable. Much pus in the tympanic cavity; its mucous membrane thickened. The same is true of its continuation into the cells of the mastoid process. Canalis facialis in the cavity of the drum exposed. The porus opticus internus and the nerves contained in it intact. The remaining portions were, for the sake of preserving the preparation, not examined. The other conditions are detailed in the account of the examination of the brain.

In regard to its genesis, this case coincides throughout with Case I. The cause of the fatal issue is also the same in both. The connective tissue extending from the tympanic cavity and the mastoid cells to the dura mater plays the principal part in the propagation of the purulent inflammation to the brain.

CASE III.—*Repeated purulent discharge from the left ear Polypus in the external meatus. Perforation of the membrana flaccida. Adhesion of the thickened membrana tympani to the promontory. Hypertrophy of the mucous membrane of the tympanic cavity. Retention of pus with formation of cholesterine in the pneumatic cavities of the middle ear. Congestive phlebitis in the left sinus lateralis with thrombosis and abscess in the walls of the sinus. Meningitis cerebralis.*

I owe the clinical history of this case to Prof. Friedreich. The pathological preparation is in the Heidelberg Pathological Institute.

Otto Zarnak, 20 years old, butcher, from Pottwitz, was brought, on the 30th of June, 1877, to the medical clinic of the Academical Hospital, after he had on the same day come to the Dispensary. The patient had already as a child heard badly on the left side. Three years before, he had suffered for eight days with earache, accompanied with discharge. For eight days he has been again suffering from the left ear. For three days, headache, especially in the back of the head. His travelling companion stated that the patient had been on a journey on foot for three weeks and had always been well. For a week, the patient had complained of violent tearing earache and diminution of appetite. Yesterday he came from Schwetzingen to this place on foot; since day before yesterday he has complained of great prostration and pain in the head, especially in the occipital region and top of the head, while the earache disappeared three days ago. He cannot move his head on account of the pain. Four days ago, slight chill, yesterday morning a heavier chill. Yesterday evening and this morning, vomiting. Since the earache has set in, sleep disturbed; especially for the last two nights has he been restless. Last night slight ravings. For three days slight discharge from the left ear, with the appearance of which the earache abated, but the headache set in. Bowels constipated for three days. He does not remember that he has had any disease, such as scarlatina, typhus, etc.

Status præsens.—No hearing-power on left side, even by bone conduction.

Head movable laterally, but backward and forward only slowly and with great pain. Skin temperature considerably elevated. Tongue thickly coated. A red tumor with a broad base springing from the depth of the left external meatus, completely filling it; meatus also contained some thick pus. Membrana tympani defective.

Clinical diagnosis.—Otitis media purulenta sinistra cum granulatione. Meningitis cerebro-spinalis.

Therapeusis.—Ice bladder to the head. Bath 28° R. with irrigations. Iced lemonade. Calomel 0.3 every two hours. Iced milk.

Examination of the other organs gave the following: Heart normal. No dullness over the lungs. Normal vesicular respiration. At the back, on both sides, some dry rhonchi. Liver not enlarged. No abdominal swelling. Pain on pressure in the region of the cæcum, and gurgling. Spleen apparently enlarged. A distinct roseolar spot in the epigastrium.

12 M.—Temp., 39.4. Bath temp., 38.4.

2 P.M.—Temp., 39.0. Pulse regular, soft and full.

4 P.M.—Temp., 39.0.

6 P.M.—Temp., 39.3. Pulse 74. Violent pain in occiput. Some slight vomiting from the calomel. Many soft stools.

8 P.M.—Temp., 39.7.

10 P.M.—Temp., 39.

12 MIDNIGHT.—Temp., 39.

July 1st, 2 A.M.—Temp., 39.

4 A.M.—Temp., 38.8.

6 A.M.—Temp., 39.0.

8 A.M.—Temp., 38.7. Pulse 76. Patient groans and moans with headache, especially in the occiput and vertex. The spinal column and cranial bones somewhat tender on pressure. No unequality of pupils. Tongue thickly coated. Constipation. Urine clear, sp. gr. 1030, no albumen. Reflex action from the sole of the foot increased. None from the patella. Ordered: Acid muriat., 2.0; aq. dist., 150.0; syr. rub. ib., 30.0; every two hours.

10 A.M.—Temp., 39.0.

12 M.—Temp., 38.

2 P.M.—Temp., 39. Bath with irrigations well borne. Pain somewhat mitigated.

4 P.M.—Temp., 38.8.

6 P.M.—Temp., 38.7. Cervical muscles tolerably stiff. Toward evening the violent headache returned, so that the patient screamed outright and sprang out of the bed. A remission after a subcutaneous injection of 0.005 of murias. morph.

8 P.M.—Temp., 40.4. Violent chill of one-half hour's duration, slight delirium. Convulsions.

10 P.M.—Temp., 40.

12 MIDNIGHT.—Temp., 40.6. Bath temp., 38.4.

2 A.M.—Temp., 38.6. Died at 3 o'clock with sudden strong palpitation of the heart. Dyspnœa and opisthotonos.

Sectio cadaveris made seven and a half hours after death by Prof. Arnold.

Calvaria of medium thickness, tolerably compact. Sutures normal. Moderately deep pits on the inner surface. Fresh coagula in the sinus longitud. Veins of the pia mater filled with blood. The pia mater itself was strongly injected, diffusely opaque with yellow discolorations in spots. On removal of the brain, the dura mater covering the left petrous bone was found to be covered with pus over quite a large extent, infiltrated, and partially destroyed, so that by pressure pus flowed out as from an abscess. The tentorium, on the inner surface of its left half, was extensively covered with pus, while on its outer surface only red spots and ecchymoses were to be seen. The meshes of the pia and arachnoid showed, on the pons, the chiasma nerv. opt. and crura of the cerebellum, a very considerable purulent infiltration, which extended over the entire surface of the cerebellum. The convolutions are flat and closely compressed. The lateral ventricles somewhat distended with turbid serum. Ependyma slightly turbid. Substance of the cerebrum, in general, moderately congested and very soft. The pia mater covering the art. foss. Sylvii sinistra infiltrated with pus. The immediate examination of the temporal bone, which is now in the museum of the Pathological Institute, gave :

At the base of the petrous bone, at the edge of the sinus transversus, opposite the semicircular canals, was found a greenish-yellow convex nodule with a slit-like opening directed toward the upper angle of the temporal bone, from which, on pressure, much pus and sanious matter flowed. On cutting this nodule, it was found to be a distention of the sinus lateralis, to whose inner surface a large discolored thrombus adhered. On detachment of the so altered sinus, the roof of the sulcus lateralis and the bone in its immediate vicinity were found to be of a bluish color, somewhat rough, and at various places small openings, from the size of a pin's head to that of a millet-seed, were to be seen.

On the posterior wall of the external meatus, where the cutaneous passes over into the osseous portion, there sprang a broad-based bluish-red tumor, the size of a horse-bean, with two roots, from near the annulus. Between these two roots the periosteum of the osseous meatus is loosened to the extent of the size of a pea, and the bone is rough. The greater portion of the remaining part of the external meatus is filled with an inspissated purulent mass.

In the membrana flaccida there was a perforation the size of a pea. The remainder of the membrana tympani, the malleus portion of which was not visible, was thick, red, and adherent to the wall of the labyrinth. The incus, detached and much altered by caries and necrosis, was imbedded in the mass filling the tympanic cavity. On account of saving the specimen, the region of the stapes and labyrinth were not examined (for the elucidation of this case of secondary importance). Rosenmüller's fossa bluish-red and contained some mucus.

The mucous membrane of the Eustachian tube pale-red ; in the cartilaginous, and more especially in the osseous portion it is filled with mucus. The mucous membrane of the osseous portion thickened ; the thickening continues without interruption to the mucous membrane of the tympanic cavity. The whole of the pneumatic space of the middle ear was partially filled with pus, but for the most part with cholesterine masses (as the microscope showed). The region posterior to the upper semicircular canal was of a slight grayish color, and somewhat thinned.

The formation of cholesteatomas in this case I look upon as *secondary* rather than *primary*, due principally to the incomplete discharge of the matter resulting from the repeated purulent inflammations from the middle ear, in consequence of the adhesion of the membrana tympani to the promontory. The propagation of the inflammation was along the connective-tissue fibres found in the fine canals of the lateral sulcus, which canals also transmit small osseous veins. The roughening of the lamina vitrea is due to the corroding action of the pus on the wall of the sinus. Caries, in the strict sense of the term, was not present.

The clinical picture of phlebitis of the sinus lateralis was in this case not sharply defined, but is justly inferred from the presence of the meningitis.

It is important to note the complete absence of any symptoms on the part of the mastoid process; and whether by an operative procedure on the mastoid process, if the disease (without any symptoms) could have been diagnosed, the life of the patient would have been saved, is quite uncertain.

CASE IV.—*Purulent discharge from the left ear, at the age of ten years. Subsequent apparent cessation. In the thirtieth year, numerous polypi in left tympanic cavity. Central and peripheral caries of the mastoid process, with burrowing abscess in the occiput. Cure after the removal of the polypi and perforation of the mastoid cells. Good health for two years. At this time caries in various portions of the temporal bone. Circumscribed left-sided basilar meningitis. Phlebitis and thrombosis of the sinus lateralis, and the sinus petrosus superior sinist.*

Some of the symptoms of the last illness: Continuous diffuse headache. Œdema of the temporal region. Stupor during the last twelve hours of life.

I saw the patient, whose case we now consider, for the first time two years before his death, on the evening of the 20th of November, 1875, in his home at Wertheim, whither I was called by his family physician, Dr. Hofmann.

The patient, a merchant of 35 years, states that since his tenth year he has suffered from a discharge from the left ear, which in latter years, up to August, 1875, had apparently entirely ceased. About that time he had an attack of vertigo, followed by pain in the deep parts of the ear, which extended to the temple and the vertex. There was a remission in its intensity, but it has never ceased since, and within the last week it has become complicated with a continuous, moderately intense supra-orbital neuralgia. About the middle of August, there appeared, in connection with the pain behind the ear, a gradually enlarging painful tumor, and with the enlargement of the tumor in the direction of the medial line, a strong pulsation in the back of the head. Further subjective sensations of hearing are not present. An incision made by his family physician over the mastoid process had little effect. A closer examination revealed total extinction of the hearing power (now and later). On the mastoid process, a moderately elevated, red, slightly fluctuating swelling, which in its extension toward the vertex and maxillary region was pale, flat, and hard, and toward the occiput much resembled the swelling over the mastoid process (burrowing abscess ?).

In the centre of this last intumescence was a wound about $\frac{1}{4}''$ long, from which on pressure (which was somewhat painful to the patient) a good deal of healthy pus escaped.

In the outer part of the meatus only a small amount of pus. The deeper parts were filled with a number of granulations, so that it was impossible to form a judgment as to the condition of the membrana tympani or the tympanic cavity.

The expression of the patient's face was anxious, the pulse 136, temperature 37.8. No chill at any time, and all the functions properly performed.

On the following morning I removed the granulations with Blake's snare; I then made with a strong scapel two long, deep, parallel incisions in the tumor of the occipital region, enlarged the opening in the mastoid downward and made it deeper. With the knife I could easily penetrate the already softened mastoid. On examination with the finger, there was found a separation of the periosteum from the peripheral portions of the bone, and the bone itself was rough, also central and peripheral caries (this latter due most probably to the corrosive action of the pus retained notwithstanding the previous incision). After I had made the new incision in the mastoid, injections of warm water were used, the greater part of which ran out through the external meatus. I left the day of the operation.

Dr. Hofmann carried out the treatment we had agreed upon, viz., he incision in the mastoid to be kept open and the secretion in the outer ear and in the antrum and cells of the mastoid to be removed by injection of warm water.

On the 28th of February, 1876, the patient came to Heidelberg. The wound had cicatrized well, and there was no return of the polypoid growths. For some weeks he had resumed his business, but he has never been entirely free of discharge from the ear. Only the handle portion of the membrana tympani was visible, the wall of the labyrinth red and thick. The source of the suppuration was still in the middle ear. Ordered alternate injections of alum and weak carbolic acid solution. Some discharge still remaining, he came to me and remained under my care from the 11th to the 31st of July of the same year. Condition the same as on February 28th. Neither objectively nor subjectively were there the least symptoms of caries. Yet I was not able, by any of the ordinary means, though used of various strengths, to stop the discharge, and B. was instructed to keep the ears scrupulously clean and employ various astringents. His general condition continued excellent. He fulfilled all the duties required in his business. About 17 months later, on the 21st of December, 1877, he came to me again.

According to his statement, up to the 9th of December, he was perfectly well and attended to his business as usual. On that day, after a long walk, he was exposed to a violent wind storm. On the following day he felt, "for the first time in two years," pain, occasional throbbing in the left ear, and heavy dull pain in the forehead and occiput. He had fever, and suffered from loss of appetite and sleep. After a time there appeared a cylindrical swelling in the temporal region, reaching to the front of the ear in the vicinity of the tragus, on account of which he consulted his family physician, Dr. Rebstein (Dr. Hofmann having removed to Eppingen). On the ninth day after the exposure to cold, a profuse discharge set in from the left ear, which, in the course of the next day, diminished somewhat. The pain in the ear completely subsided, but the above-described headache remained; no return of appetite. Bowels regular. Loss of interest and pleasure in business. Patient came here on the afternoon of the 20th of December, the journey occupying six hours. He came to see me at my house on the morning of December 21st.

Status præsens.—Aside from the cicatrices of the former incisions, there was nothing to note either on the mastoid or occiput. *In the temporal region above the pinna a diffuse œdematous, painless, whitish swelling, which passed downward to the region of the tragus and was lost there.* Only a little pus in the external meatus. In the middle on the upper posterior wall a red, prominent, soft spot. When I pressed on this with the sound, much pus flowed out, and the sound passed through a carious opening upward and backward. After the incision into the tumor I was not able to find the opening where the sound had passed through; the tumor filled rapidly again after syringing the ear and remained so till death, as did also the slit-like narrowing of the meatus caused by it. Nowhere any pain on pressure. He was very much affected by the syringing, though I did it very gently, but soon he expressed himself as feeling better. Pulso 100, temperature 38.6°. Prescribed: Confinement to bed, ice, restricted diet. At my evening visit, pulse 100, temperature 39.6°. Dull heavy pain in the whole head. Otherwise *in statu quo.* Same prescription.

December 22d, morning.—Sleepless night. Violent diffuse headache. Spontaneous normal stool. Action of the *pupils normal.* Temp. 38.6°, pulse 96°, otherwise the same. 5 P.M., temp. 40°, pulse 100°. Continuous diffuse headache. Locally the same. Treatment continued. At 9 P.M., complete consciousness: to the waiter of the hotel who asked him if he wished anything, he answered, "No, except to sleep." During the night of 22d to 23d of December, he became unconscious; the pupils on both sides became small and reacted tardily. Cramps of the upper extremities. Continual moaning. Pulse 120°, weak. Temp. 40°. Died about mid-day.

Sectio cadaveris 24 hours after death by Dr. Mays; the cranial cavity alone examined.

At 3, resp. 4, cm. behind the left pinna, there are two parallel cicatrices close together; the underlying tissue somewhat thickened and closely united with the bone. On the convexity of the brain, the dura mater is moderately, and the pia mater strongly injected. The veins of the latter broad and full of blood. The brain-substance is œdematous and rather pale. In the distended lateral ventricles much turbid serum. The ependyma slightly turbid. The dura of the left posterior cranial fossa thickened, discolored, and infiltrated with pus, as was also the pia mater of left cerebrum and cerebellum. The cortex of the cerebellum in many places is of a peculiar grayish-yellow color; a similar discoloration is also found in some places in the cortical substance of the base of the cerebrum. The outer wall of the sinus transversus is discolored and irregularly granulated from connective-tissue hypertrophy. Some large granulations correspond to the adjacent carious openings in the petrous bone (see the section of the temporal bone). The cavity of the sinus transversus is obliterated by a deep-red thrombus firmly attached to its walls and extending up to near the foramen jugulare. In the sinus petrosus superior was a white thrombus firmly attached to its walls.

Carious spots were found in the following different portions of the temporal bone:

1. One, the size of a pin's head, ½ cm. behind the eminentia arcuata.

2. A centimetre behind this, one the size of a pea. This is separated by the angle of the petrous bone from one

3. Double as large, which lies in the angle where the descending part of the sinus transversus passes into the horizontal. 2 and 3 are situated in a common space, which, lying at the base of the temporal bone, is filled with a partially inspissated mass of pus.

4. At the point of discharge of the vena emissaria Santoriniana, one the size of a lentil.

5. Various others of smaller size in the walls of the sulcus sigmoideus.

6. In the osseous meatus, about the beginning of its inner third on the upper posterior wall. In this opening, the size of a pea, a sound can be pushed in an oblique direction toward the base of the temporal bone, and passed into the carious openings 2 and 3.

The external meatus itself contains only a little pus. The integument of the upper posterior wall is thickened, of a somewhat bluish color, and in the immediate vicinity of the carious places stands up from the bone which is deprived of its periosteum. Of the membrana tympani, all is gone up to the handle of the malleus. Incus is wanting. The cavity of the tympanum, the antrum mastoideum, as well as the pneumatic spaces of the pars petrosa et mastoidea are filled with partially inspissated pus. The periosteum of the outer surface of the mastoid process is closely attached to the bone-substance. The mucous membrane of the labyrinth is red and thickened. On account of preserving the preparation, the labyrinth was not examined.

From both a clinical and practical point of view the above case is highly instructive.

Clinically, as regards the fatal cerebral affection, the complete absence of pronounced symptoms of phlebitis of the sinus is remarkable. Aside from the pain in the forehead and occiput at the beginning of the trouble, which toward the end passed into a continuous diffuse headache, which could be referred to a meningitis, there was present only *œdema of the temporal region*, which, to my knowledge, has not hitherto been described as a symptom of phlebitis of the lateral sinus. I consider this a *most important symptom, but not pathognomonic*, because we cannot exclude the possibility that it is not the consequence or accompaniment of caries of the squamous portions of the temporal bone, or an abscess of the temporal lobe. This symptom as a result of a phlebitis or thrombosis of the lateral sinus stands in a line with the œdema of the mastoid region (Griesinger) and that of the eyelids and globe (Heubner).

As regards the symptoms of caries, the almost latent course it pursued is also remarkable, and so much the more so as the section showed so many smaller and larger carious openings. Though the earache, at the last exposure to cold, continued for eight days, it can hardly be supposed that the carious process could have set in at so many different points at once. On the other hand, it would be astonishing if the process had been latently progressive during the time since I last observed the patient—seventeen months—without his being in any way inconvenienced or hindered in his daily avocation, as he certainly was not.

But such a gradual, latent destruction of a temporal bone does not seem so impossible when we remember that the patient during a series of years—from his 16th to his 35th year—had suffered from purulent inflammation of the ear, to which was added subsequently an acute inflammation of the bone, which was several months in healing. All these are processes which leave behind them a softened and diseased condition of the bone which is favorable to a painless, but rapid and multiple carious destruction.

The case also teaches us how careful we should be in making our prognosis *quoad vitam*, so long as there remains the least purulent discharge from the ear, even when the diseased process in the bone is cured, no matter according to what method in a given case the mastoid cells have been opened. The principal thing to do is to keep the opening in the bone patent, and to remove the inflammatory products from the pneumatic spaces through an uninterrupted communication between the opening in the mastoid process and the middle and outer ear. These indications were certainly closely followed out in the after-treatment for two years before his death without bringing about a complete resolution of the purulent inflammation.

In regard to the treatment of the case in its last stages, it was an easy matter to enlarge the carious openings in the external meatus, and to remove through them the inflammatory products from the pneumatic spaces; but already on the morning of the 21st of December, I regarded the case, surgically considered, as a *noli me tangere*. Up to this time I had thought of a complicating brain-trouble as likely in the near future, but had no idea that it was already established. And yet the patient, as the condition of the thrombus showed, had now for several days been laboring under a phlebitis and thrombosis of the lateral sinus. Indeed, so relatively symptomless was this affection that we came near being led into the above-mentioned operative procedure, which, however, would certainly not have prolonged his life, but on the contrary, would probably have cut it even shorter.

(*To be continued.*)

ON THE COMBINED OCCURRENCE OF AFFECTIONS OF THE ORGANS OF SIGHT AND HEARING.

By Prof. S. MOOS.

(Translated by H. Knapp.)

In the course of the last years, a limited number of cases have come under my notice, in which the visual and auditory organs were simultaneously affected. In describing them, I less desire to convey instruction than to draw the attention of the profession to these combined disturbances, and give an incentive to further study. Though the number of cases which have come under my observation is small, and I am unable in some of them to furnish an explanation of the connection of the symptoms, I thought I should no longer delay their publication, since with the present volume this journal will cease to be an organ of ophthalmology and otology combinedly. Availing myself of this last opportunity, I beg the indulgence of the reader for introducing a subject which scarcely yet seems prepared for discussion, in particular with regard to certain ocular disturbances in Ménière's disease.

Pathological phenomena relating simultaneously to the organs of the two higher senses are, in general, not very rare, and depend on constitutional as well as local diseases. The general disturbances are chiefly dependent upon constitutional diseases, especially scrofulosis and syphilis. Under the name of otitis in connection with ophthalmia, Wilde described a number of cases of hardness of hearing in scrofulous persons, who at the same time suffered from corneitis or irido-choroiditis. In secondary syphilis the organs of both the higher senses are frequently affected at the same time, or the one shortly after the other. A remarkable case of this kind has been described by H. Knapp

(9 *a*,[*] pages 315 and 321). It was a case of so-called Ménière's disease, which soon after the onset of the aural affection was complicated with exudative choroiditis. The same author (9 *b*) reports on another case which he saw in the practice of Dr. Swansey of Dublin. The patient suffered from serous iritis and parenchymatous keratitis, together with the symptoms of Ménière's ear-disease, and both the eyes and ears were cured by anti-syphilitic treatment. A most remarkable case has of late been published by Bramwell (31). It was one of obstinate syphilitic periostitis of the left temporal bone connected with epileptic seizures, during which the patient lost consciousness, further with right-sided post-epileptic hemiplegia and post-epileptic aphasia, distorted right pupil, binocular neuro-retinitis, complete deafness, and loss of bone conduction on the left side. After repeated relapses and repeated and long-continued treatment with large doses of iodide of potassium (ʒ ss. 3 times daily, for weeks), the general health and the impairment of sight were considerably improved, "and the power of hearing was returning in the left ear."

The local phenomena may be produced by pathological processes in the cranial cavity and diseases of the visual organ, complicating themselves with an aural affection and *vice versa*.

Among the pathological processes in the cranial cavity may be mentioned:—meningitis, new formations, diseases of the cerebral sinuses not originating in the ear (Wreden, 20), and finally those cases in which the clinical history leaves no doubt as to the presence of an intracranial affection, without, however, admitting of a special diagnosis (Schwartze, 33 *a*, and Brenner, 21).

Combined visual and auditory disturbances occur both in sporadic and epidemic meningitis. The subsequent impairment of hearing is only exceptionally of a low degree, absolute deafness being the rule. It is chiefly caused by purulent inflammation and its consequences, either at the origin or in the course of the acoustic nerves, or in the labyrinth, sometimes also in the drum cavity. The causes of the impairment of sight are either purulent choroiditis (Knapp, 9 *a*, page 297, etc.), or neuro-retinitis, in consequence of neuritis descendens (Schirmer, *c*, in Knapp's paper, 9 *a*, p. 301).

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[*] The numbers in brackets refer to the record of literature at the end of this paper.

VISUAL AND AURAL DISTURBANCES AS SYMPTOMS OF INTRA-CRANIAL TUMORS.

Statistical Statements.

According to the tabular statement of Lebert (4), the sense of sight suffered in 40 cases out of 45 affected with disturbances of the organs of special sense. According to Friedreich (5), in 26 cases out of all he was able to collect; according to Ladam (8), 171 out of 331 cases suffered from ocular symptoms, among which 60 from amaurosis. The greatest number of visual disturbances is recorded in the tabular statement of Reich; among 88 cases of cerebral tumor, in which the ophthalmoscopic and post-mortem examinations had been made (on account of which these statistics are the only reliable ones), there were 95.4 per cent of papillitis or papillitic atrophy, leaving only 4.5 per cent where no change was found. (Quoted from Leber, 16.)

Aural disturbances are stated by Calmeil (2) to occur in $\frac{1}{9}$ of all the cases; by Lebert in 11 out of 45; by Ladam (8), in 31 cases out of 331.* In 5 of Ladam's cases, auditory disturbances were present without disturbances from any other organ of special sense. Complete deafness occurred in 17 cases, in one, however, only temporarily. The auditory disturbances, in the other cases, were: simple impairment of hearing in 9 cases, tinnitus aurium in 6, hallucinations in 2. In one case, tinnitus aurium was, for a long time, the only symptom, lasting seven years; in another case, it was the only disturbance on the part of the organs of special sense during the whole disease.

Auditory disturbances occurred, according to Ladam's statistics:

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* Case 279 of Fischer and Traube has to be deducted, for the impairment of hearing resulted from otitis media purulenta, which led to the diagnosis of a cerebral abscess. The autopsy, however, showed a sarcoma under the right tuber parietale.

In 7 out of 77 cases of tumor of the cerebellum . . = 9 %.
“ 9 “ “ 36 “ “ “ “ “ pons . . . =27 %.
“ 5 “ “ 13 “ “ “ “ “ middle cerebral fossa =38.5%.
“ 2 “ “ 14 “ “ “ “ “ pituitary region . =14 %.
“ 3 “ “ 27 “ “ “ “ “ middle lobes . . =11 %.
“ 6 “ “ 52 “ “ multiple tumors* . . . . =11.5%.

In Ladam's statistics it is very remarkable that there was total absence of auditory disturbances in 7 cases of tumor of the crura cerebri; in 15 cases, of tumor of the corpora striata and thalami optici; in 4 cases, of the corpus callosum; in 27 cases, of the anterior lobes; in 19 cases, of tumor in several lobes; in 17, tumors of the convexity, and in 4, tumors of the fourth ventricle, from the size of a bean to that of an egg. Despite the striæ acusticæ in the fourth ventricle, absence of auditory disturbances seems to be the rule in these cases; for instance, in Mosler's case, the autopsy of which was made by Virchow. Magnicellular glio-sarcoma, 5 cm. long, 1 cm. thick, 1.5 cm. high. (Virchow's Archiv, Vol. XLIII., p. 220, etc.)

In Ladam's treatise I count 25 cases of combined affections of the visual and auditory organs; they refer mostly to tumors of the basis of the brain, especially when they reach far forward and occupy the greater part of the basis. Lebert (4) found in such cases both organs of special sense affected eight times; further in tumors of the pons or the acoustic trunk, as, for instance, in the cases of Lévêque-Lasource (3), and Böttcher (10), and in my own case (11 *b*); moreover, in the 22d case of

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* 305. Durand-Fardel, Journal Hebd., No. 35, 1836. Encephaloid tumor, the size of an apple, between dura mater and arachnoid, at the level of the right posterior lobe; at the anterior part a similar tumor, the size of a walnut, left drum cavity filled with a similar mass. Deafness on the left side, later also on the right. Blindness.—307. Tinnitus aurium, two large tubercles in pons. Gelatinous exudation on the basis of the brain.—308. Tinnitus aurium and impairment of hearing on the left side. Tumor in the occipital fossa.—312. Loss of hearing. Tubercle in the upper part of the left posterior lobe, another at its basis on the tentorium.—320. Hardness of hearing. Four tumors. A node in the anterior cerebral lobe; the second in the hemisphere of the cerebellum; third in the optic thalamus; fourth in the right posterior lobe.—325. Impairment of hearing. Three tumors: in right middle lobe, in right hemisphere of brain, and in posterior lobe.

Petrina (13) and in an exceedingly rare case of Wreden (20*b*) in which there was a pseudoplasm in the anterior part of the skull causing secondary thrombosis of the transverse and cavernous sinuses, and consequent disturbances of the senses.

Statistics show that in tumors of the brain the eye is not only more frequently, but also more severely implicated: 60 times amaurosis among 331 cases of Ladam, and the statistics of Reich (16) are still worse. The eye affections are also much more frequently bilateral than the ear affections.

Total deafness occurs mostly on one side only; in the majority of cases there is hardness of hearing in different degrees, and "frequently we can hardly conceive how the hearing can be preserved when voluminous tumors in the pons or its nearest vicinity are present" (Hasse, 6, p. 557).

RELATION BETWEEN THE FUNCTIONAL DISTURBANCES AND THE DEVELOPMENT OF CEREBRAL TUMORS.

a. The functional disturbances of the visual organ are, as is well known, the result of pressure of the tumor on the motor nerves of the eye, and (see Leber, 16) of the increase of intracranial pressure, causing penetration of the cerebro-spinal liquid into the interstices of the optice nerve, dilatation of its sheath, compression of the intraocular end of the optic nerve, "hydrops of the sheath of optic nerve" (H. Schmidt), and, dependent on it, the papillitis or papillo-retinitis with its consequences, first described by v. Graefe, and of the greatest importance in the diagnosis of cerebral disease. It also frequently happens that an inflammatory process in the vicinity of the tumor extends to the optic nerve: neuritis descendens with its consequences. Finally it may occur, as Türk has first shown (Leber, 16) that hydrocephalus internus, either primary or consequent upon intracranial tumors, enlarges the third ventricle, the lower end of which then may press upon the chiasm and occasion its degeneration or atrophy, which may extend centrally over the whole course of the tract, or peripherally over both optic nerves. In this way simple atrophy of the optic nerve may occur without any pressure on the nerve (Böttcher's case 10).

b. The functional disturbances of the auditory organ are: subjective sensations of sound of the most varied character, which may occur at the beginning of the cerebral affections, together with the irritative symptoms and the congestion of the brain, and then disappear; sometimes auditory hallucinations (2 cases Ladam, 8); great sensitiveness of noises, together with photophobia (one case of Ladam, 130); more or less pronounced impairment of hearing; absence of bone conduction; total abolition of hearing. In some cases, one-sided functional disturbances of the auditory organ were the initial symptom of an intracranial pseudoplasm. These symptoms, taken alone, present nothing characteristic of the diagnosis, since they occur also in peripheric lesions of the auditory organ; beating in the occiput, however (Griesinger, 7), which has been observed in several cases, is remarkable as an initial symptom of aneurism of the basilar artery.

The functional auditory disturbances may be caused:

1. *In the brain*, by compression of the acoustic nerve, either at its origin or in its course (pressure-atrophy); by total destruction of the nerve-trunk, as in the case of Brückner (17), in which the trunk was torn off by the tension of the tumor; further, as in aneurism of the basilar artery, by embolism or thrombosis of the basilar and the internal auditory arteries, or of small branches of the basilar artery supplying the acoustic nerve (all these processes cause atrophy of the nerve); further, by apoplexy or softening of the pons complicating the development of the tumor.

2. *In the labyrinth*, by collateral fluctionary disturbances accompanying the increase of the tumor, by stagnation of blood in thrombosis of the cerebral sinuses (Wreden, 22 *b*), and by atrophic changes in the labyrinth. In this way Böttcher (10) has found atrophy of the inner and outer auditory cells, apart from the destructive pressure exerted by the tumor penetrating through the lamina cribrosa into the labyrinth. I have observed (11 *a*) degeneration and atrophy of the whole organ of

Corti. In the cases hitherto published, an examination of the auditory organ * has unfortunately been neglected. In spite of this, I will give an extract of them on account of other points of importance they present.

In the case of Hubrich (12), there were pain behind the ear, repeated attacks of tinnitus, later on, vomiting. Manifold disturbances in the peripheric motor nerves, the sensibility being intact. A week before death, an attack of loss of consciousness, delirium, convulsions, and temporary blindness. Autopsy: At the base of the brain, starting from the cerebellum, a glioma, the size of a walnut, crowding the medulla oblongata aside, pressing upon the origin of the facial and acoustic nerves and pushing them forward.

In the 21st case of Petrina (13), great hardness of hearing, convergent strabismus and apoplectic retinitis on the left side. The autopsy showed, as the cause of these symptoms, a neuroma of the left trigeminus, the size of a walnut, compression and softening of the left hemisphere of the cerebellum, compression of the left crus cerebelli ad pontem and the left half of the pons.

In the 22d case of Petrina, there was impairment of sight, slowly increasing during five years, double-sided exophthalmus, atrophy of the optic nerve, considerable hardness of hearing, and opacity and slight maceration of the cornea on the right side. Autopsy: Neuroma of the right acoustic nerve, the size of a pigeon-egg, compression and softening of the hemisphere of the cerebellum, the crus cerebelli ad pontem, the half of the pons, and flattening of the pedunculus cerebri on the right side.

Fox (14) describes a case of right-sided neuritis, left-sided atrophy of the optic nerve with impairment of hearing. Autopsy: glioma of the left half of the cerebellum and flattening of the pons Varolii.

Hulke (15) describes an intracranial sarcoma, without any symptoms on the part of the motor and sensitive cerebro-spinal nerves. There was, however, paralysis of several cranial nerves, diplopia from paresis

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* The statement of loss of hearing is without value if no examination of the auditory organ was made during life, as is illustrated by a striking case of Hinton (32). In a case of cerebral tubercle, he examined the petrous bones expecting to find changes in the drum cavity which frequently accompany cerebral tuberculosis, but found a "sebaceous tumor" in the right tympanic cavity. During life (an examination had not been made), not a single symptom betrayed the existence of the tumor.

of the left abducent and oculo-motor nerve, simultaneous contraction of the left pupil, and subsequent left-sided exophthalmus,* neuro-retinitis, considerable impairment of hearing on the left side, and the symptoms of the so-called trigeminus-ophthalmia. Autopsy: A sarcoma, starting from the apex of the petrous bone, destroying Gasser's ganglion, the cavernous sinus, and the motor nerves of the eye. The tumor penetrated into the orbit through the sphenoid fissure, and from there into the anterior cranial fossa, and extending backward, involved the facial, acoustic, and hypoglossal nerves.

Finally, I will mention a case of Leber (16, p. 784) which terminated favorably:

"For more than three years I watched another case in which, from the symptoms, I diagnosticated a tumor. The double-sided choked disc, very marked in the beginning, gradually passed over into atrophy, leaving only slight traces of the former inflammation. Besides the double-sided papillitis with slight amblyopia, transitory obscurations and photopsiæ, there were attacks of intense headache (which, however, are said to have been present already in childhood), very pronounced humming and singing in the ears, paresis of the internal rectus, and repeated temporary numbness of the left half of the face. Under the use of iodide of potassium all these symptoms gradually improved, no history of syphilis being present; the vision grew normal on the right side and $=\frac{2}{3}$ on the left; only the humming in the ear has not yet totally disappeared."

The difference in the relative frequency of affections of the visual and auditory organs is very remarkable. According to trustworthy authors (conf. the compilation of Leber, p. 778: papillitis in circumscribed lesions in the cranial cavity), cerebral tumors are almost always connected with disease of the optic nerve† (95.4 per cent of papillitis or papillitic atrophy, according to Reich), and optic neuritis is chiefly the consequence of increased intracranial pressure, whereas disease of the acoustic nerve is noticed only in 11 per cent (Ladam) to 28 per cent (Leber) of cases of intracranial tumor. Bearing this disproportion in mind, we may fairly ask the question, Is there a true labyrinthine neuritis as the consequence of increase of intracranial pressure, or are the anatomical relations between the acoustic nerve and the central nervous system, are further the conditions of circulation and pressure in the labyrinth so much more favorable than those of the optic nerve and retina, that in the inner ear the above-mentioned disturbances of pressure can be more rapidly compensated, or are altogether without importance? The anatomical and experimental investigations of this subject are unfortunately too scant to admit of a brief answer to this question. In the following pages I will review the present status of this question and point out what problems, in this regard, we have still to solve.

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* In the preceding number of these ARCHIVES I have described a case in which a tumor, extending from the naso-pharyngeal into the cranial cavity, likewise caused exophthalmus, neuro-paralytic ophthalmia, and considerable impairment of hearing.

† As to the frequency of disease of the optic nerve in intracranial affections in general, compare the appendix to this paper.

According to the researches of Schwalbe and Böttcher, a funnel-shaped prolongation of the arachnoid enters the internal auditory canal together with the facial and acoustic nerves, thus establishing a chief communication between the perilymph of the labyrinth and the arachnoidal fluid. This anatomical condition renders a propagation of the intracranial pressure to the labyrinth possible and *vice versa*. Moreover, Prof. Hasse (26) has ascertained that in the vertebrates, the human embryo, and probably also in the full-grown man, the aquæductus vestibuli, after emerging from its aperture, enters free into the space between the dura mater and the cerebral cavity, and, dilating in the shape of a funnel, coalesces with the envelope of the brain, and opens at the side of the cerebellum into the cavum epicerebrale. Key and Retzius (27) could not detect a connection between the ductus endolymphaticus and the subdural and arachnoidal cavities, but they observed that injections into the subdural and subarachnoid cavities penetrated with the acoustic nerve partly into the lamina cribrosa, and partly also into the perilymphatic cavity of the labyrinth. They could, however, not ascertain whether the liquid passed through the aquæductus cochleæ (ductus perilymphaticus). Weber-Liel (29) asserts, however, in a preliminary communication, which, up to this day (almost two years), has not been followed by a detailed description, that the possibility of liquid passing through the ductus perilymphaticus is almost a certainty. According to Weber's investigations of the auditory organs of the full-grown man, the aquæductus cochleæ connects the perilymphatic cavities of the labyrinth with the arachnoidal cavity, whereas the aquæductus vestibuli connects the endolymphatic cavities with a sac situated between the leaves of the dura, which, however, is not to be considered as a cul-de-sac; but this part has before Weber been described as a cul-de-sac by Zuckerkandl (28), and this has been confirmed, though not as of constant occurrence, by Rüdinger (30). This author leaves also undecided, whether in man the intracranial part of the aquæductus is, during life, filled with liquid, and capable of producing variations of pressure in the vestibule, or not.

It follows from all this that the relations between the intracranial and the labyrinthine pressure are not yet sufficiently known. If clinical experience could decide this difficult problem, it would appear that increase of intracranial pressure injures the visual organ more than the auditory; in other words, that the anatomical conditions of the labyrinth afford a readier compensation of increased pressure. Such a compensation of pressure seems not impossible, even in cases of peripheric disturbance of hearing which are connected with increase of intra-labyrinthine pressure. Schwartze, as is well-known, speaks, in such cases in which the symptoms of increased pressure gradually disappear, of a tolerance of pressure (Druckgewöhnung).

Many problems in the just-mentioned subject still await their solution from anatomists, experimenters, and aurists. Aurists in particular should never let an opportunity unimproved, in which they could observe, during its whole course, a case of cerebral tumor, be it connected with auditory symptoms or not.* If disturbances of hearing are present, most careful functional examinations should be made. We do not even know whether in cerebral tumors, causing disturbances of hearing, bone-conduction with regard to all sources of sound is absent or not, while, as is well-known, in certain affections of the labyrinth, bone-conduction may partially be preserved; for instance, the tick of a loud watch may be heard, but no musical sound perceived, etc.*

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* Consult, in regard to this, the case of Hinton, in note on page 487 of this paper.

At autopsies the conditions of the trunk of the acoustic nerve should be carefully examined, since it seems not impossible to detect, in some cases of cerebral tumor, hydrops of the sheath of the acoustic nerve, just as well as hydrops of the sheath of the optic nerve. Aurists should in such cases take the same precaution which is observed by oculists, viz., ligation of the sheath of the nerve (Leber, loc. cit.). In the labyrinth, the relations of the two aquæductus, the vascularity, symptoms and sequels of inflammation, etc., should be closely investigated.

In conclusion I have to mention the observations of Brenner (21) of the coincidence of paretic or paralytic affections of the visual organ with abnormal reaction of the acoustic nerve, as caused by certain intracranial lesions. In the three cases which came under his observation, hyperæsthesia of the acoustic nerve was connected with (partially alternating) muscular paralysis of the eye. In the first two cases, a precise diagnosis of the cerebral affection could not be made; in the third case, the auditory disturbances and the alternating paralysis of the external recti of the right and the left eye were the precursors of a right-sided hemiplegia, which, however, disappeared twelve hours after the patient had recovered his consciousness.

Schwartze made, in a case terminating in recovery, the diagnosis of probability: circumscribed periostitis at the basis of the skull. The symptoms were the following: sleeplessness for weeks, then headache, convulsions of the right arm and leg, falling down unconscious, formication in feet, unsteady gait, vertigo, later hardness of hearing, increasing to total deafness, tinnitis aurium of short duration. At the same time Prof. Graefe, in Halle, diagnosticated progressive amblyopia with concentric limitation of the visual field in the right eye, slight amblyopia, and slight limitation of left visual field ; in left ear no abnormity on physical examination, hearing lost. After application of Heurteloup's artificial leech, three times, complete recovery from the disturbance in both organs of special sense. The recovery was still perfect when patient was last seen, six months later.

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* We should, however, always bear in mind that, in the occurrence of disturbances in both the organs of the higher senses, the affection in one may have a peripheric, in the other a central origin. In a case of Schwartze (33 *b*), for instance, the blindness was caused by atropy of the optic nerve from encephaloid tumor in the brain the deafness by an affection of the sound-conducting apparatus.

EYE DISEASE AS THE ORIGIN OF EAR DISEASE.

I consider this kind of combined affection of the organs of the two higher senses to be the most infrequent.

In literature I have found no example of it, and have notes of one case only, which I observed in consultation with Prof. Schiff, in Florence, Italy. An English lady residing in Florence had been operated on for cataract of both eyes. Extraction correctly executed on both sides. Panophthalmia ensued, with extension of the inflammation to the base of the skull, blindness, and, finally, total deafness on both sides.

EAR DISEASE AS THE ORIGIN OF EYE DISEASE.

Dr. Charles Kipp, according to an oral communication to the writer, has observed a case of purulent inflammation of the middle ear, followed by meningitis and optic neuritis. After a longer duration, recovery from all disturbances ensued.

Schwabach (18 *a*) observed in a case of left-sided chronic purulent inflammation of the middle ear, with a large perforation of the drum-head, peculiar oscillatory movements of the eyes, which took place on both sides in the horizontal direction toward the diseased ear. They occurred only when a secondary infiltration of pus produced a high degree of swelling in and around the ear, and when the region of the mastoid process, immediately behind the auricle, or the adjacent part of the auricle itself, was pressed upon. The movement ceased at once when the pressure was left off. They occurred also, though less marked, when the ear was syringed. These movements of the eyes were accompanied by intense vertigo. Schwabach states that no such observation has hitherto been placed on record; whereas Cyon (19) produced the same phenomena experimentally, by irritating the semicircular canals in the rabbit. Schwabach thinks that also in his case the oscillatory ocular movements were produced by irritation of the semicircular canals, in consequence of the pressure from the profuse secretion of pus and the great swelling of the soft parts, transmitted through the fenestra ovalis. Of late, E. Pflüger (18 *b*) observed a case of formation of polypi on the posterior wall of the external auditory canal close to the membrana tympani. When the polypi were touched with a probe, oscillatory movements in the horizontal direction ensued in both eyeballs.

Cyon considers the movements of the eye, following the lesion of the semicircular canals, as the immediate and direct consequence of this injury. The pupil of the eye on the irritated side contracts, whereas the pupil of the other eye remains wide. A case of contraction of the pupil in purulent otitis was brought to my notice thirteen years ago, in the clinic of Prof. Friedreich, and published by me in the "Archiv für Ohrenheilkunde" (11 *a*). At that time I endeavored to account for the symptoms in a manner different from the views of Dr. Cyon, whose experiments have thrown new light on the subject. When the otorrhœa and apparently also the purulent perforative inflammation of the right middle ear had ceased, symptoms set in which made me afraid of serious cerebral complications; namely, persistent headache, vertigo, tinnitus, vomiting, and contraction of the pupil on the affected side. All those symptoms disappeared after the catheter had been applied twice, and the stowed-up masses of pus and epithelium removed. At that time I thought that the vertigo and vomiting were symptoms of increased intra-labyrinthine pressure from the products of inflammation in the middle ear, transmitted through the windows of the labyrinth, whereas I thought the contraction of the pupil was brought about by an irritative condition of the otic ganglion.

Special attention should be given to those ocular disturbances which are caused by inflammatory thrombotic processes in the transverse and cavernous sinuses, consequent upon purulent inflammations of the middle ear. (Consult the literary record, 4 *b*, 20, 22, 23, 24, 25.) The symptoms on the part of the eye are, as is well known, so characteristic that they are of considerable assistance in making the diagnosis of phlebitis and thrombosis of the cerebral sinuses, a diagnosis which, in general, is not quite easy. Heubner (22), from an observation in his own practice and clinical histories of Puchelt, Pitha, Heusinger, and Genouville, sees a very important symptom of stasis, eventually thrombosis of the sinus transversus, in the stasis of the vena frontalis, and particularly in the venous hyperæmia of the eye, complicated with œdema of the eyelids and protrusion of the eyeball, if these symptoms occur on one side only and suddenly, together with the cerebral symptoms.

Still more diversified are the pathological phenomena in the eye, if the cavernous sinus is the seat of thrombosis. In this case we may notice the following symptoms: stasis in the ophthalmic and retrobulbar veins, irritation or paralysis by pressure of the nerves passing through or near the cavernous sinus, viz., the oculomotor, abducent, trochlear, and the first branch of the trigeminus. Besides the hyperæmia of the conjunctiva, there is hyperæmia of the retina, choked disc with transitory blindness* (Wreden, 20 *a*), ptosis and erysipelatous redness of the upper eyelid and its surroundings; the protrusion of the eyeball from swelling of the retrobulbar connective tissue, strabismus, especially strabismus divergens; finally epiphora, supraorbital neuralgia, and neuroparalytic ophthalmia, as after division of the fifth pair, noticed once by Lebert (4 *b*, p. 403).

All these symptoms may either disappear (Stokes, 24) or persist until death.

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* Whether produced by venous stasis or simultaneous basilar meningitis is not yet known. (Leber, 16, p. 794.)

Disturbances in the eye, occurring in the so-called morbus Ménièri, have several times come to my notice. Ménière himself mentions obscuration of the visual field during the attack in two of his ten cases (9 *a*). According to Knapp (9 *a*), this obscuration does not lead to permanent impairment of sight. Knapp does not believe that the obscuration of sight is caused by an inflammatory condition in the eye, as hyperæmia of the retina and choroid, with exudation into the retina and vitreous, but rather by anæmia of the brain and retina during the syncopal condition in the attack. He describes (9 *a*) an observation of his own (third case), where in a marked case of Ménière's disease, impairment of hearing and sight were present. S.=$\frac{20}{200}$ in each eye, but improved to $\frac{20}{40}$ by +26. Patient read smallest type with +10, but not easily. The visual field was considerably contracted in both eyes: in the left, to a diameter of about 9″; in the right, of 6″, in a plane 1′ in front of the eye. The contraction was eccentric, the point of fixation being near the inner limit. Perception of colors perfect. Both discs white, vessels scant, arteries small, the remainder of the background normal.

In the critical remarks on this case, Knapp states that the permanent asthenopia and amblyopia were in no connection with the cerebral phenomena of the attack, but were mainly caused by the hyperopia, and the remaining slight amblyopia, in his view, resulted from a low degree of the optic-nerve atrophy, for which no cause could be detected in the eye.

In the following case, which occurred in my own practice, a chronic purulent inflammation of the middle ear was complicated in its course with the symptoms of Ménière's disease and transitory hemianopsia with a horizontal border-line.

Mr. E. Sch., 65 years old, consulted me June 11th, 1875. He had suffered for years from right-sided otorrhœa, which, however, had ceased during the last years. Some months before his presentation and after an exposure while travelling from Nice to Florence, he noticed that the otorrhœa had reappeared with considerable impairment of hearing. On June 7th, he travelled without interruption from Nice to Zurich, passed a sleepless night, and awoke with a heavy head. He expected that a walk in the open air would relieve him, but was disappointed. He felt vertiginous, and had difficulty in seeing and selecting photographs in an art gallery. On coming out of the room, he saw all objects indistinctly with the right eye. He sat down in a shady place, and took some soda-water, whereupon the dimness of sight disappeared, but left a sensation of pressure in the eyeball. The next day he travelled 8½ hours, to Heidelberg. After taking a meal and a pint of claret, he went up to the "old castle," where he arrived greatly heated. The heaviness of the head, vertigo, tinnitus in the right ear, and nausea set in again. His hearing grew worse, and he lost the sight of his right eye suddenly and in a peculiar way. Upward he could dimly see, but below it appeared as if a piece of sheet-iron was held before his eye. The vision in the left was preserved, but blurred. The obscuration in the right lasted about ten minutes, then it gave way to a general haze before both eyes, accompanied by vertigo, tinnitus, impairment of hearing and heaviness of the head, still persisting the next day, when I examined him.

Corresponding to his advanced age, patient had lost bone-conduction for all sources of sound. By air-conduction he perceived low tones at a distance of about 1′, the middle octave of a piano only close to the ear, loud voice at a distance of 1 metre.

Some fresh pus in the external auditory canal; the perforation in the anterior lower part of the drum-head plugged with pus; mucous membrane of promontory congested.

The examination of the eyes made by Prof. Becker gave the following result: M. $\frac{1}{24}$; S.$=\frac{20}{200}-\frac{20}{70}$ in either eye. The hemianopsia of the right eye with the horizontal border-line evidently depends upon transitory vascular spasm, is of no importance as to the eye, but might be in some connection with the affection of the ear. In the following two weeks, during which patient was under my care, the described attacks did not reappear. I have not heard of the patient since. The treatment improved the otorrhœa, but not the acuity of hearing. Some vertigo and tinnitus remained.

In this case the chronic affection of the ear was complicated with an attack of Ménière's disease, as is not infrequently observed. Some of the symptoms of this affection were not as marked as usual. Vomiting, for instance, was absent. Considering all the symptoms, I do not hesitate in assuming that the perforative inflammation of the middle ear was complicated with exudation into the labyrinth and disturbance of circulation in the brain and retina, causing transitory inferior hemianopsia.

In some respects this case resembles the so-called scintillating scotoma or the temporary hemianopsia (Leber, 16, p. 944), which is said to be a nervous transient disturbance of vision, which may be complicated with "vertigo, hemiplectic turns, (Szokalski, Airy, v. Reuss), formication, numbness of the extremities, even transitory hemiplegia during each attack (Mauthner), distortion of the mouth (Airy), difficulty of speech, weakness of memory and of hearing, and regular epileptic seizures" (Leber, 16, p. 947).

In the following case of Ménière's disease, the disorder of the eye, occurring simultaneously with the affection of the ear, was permanent.

R., æt. 51, merchant of Hamburg, consulted me July 5th, 1875. A year previously, after an intense mental excitement, he went into his garden, where he suddenly began to suffer from tinnitus aurium, for which he was treated by inflations during the fortnight following, but the difficulty grew worse. In the third week, vomiting, dizziness, and marked congestion of the head set in. The hearing power diminished considerably in the right ear. These seizures repeated seven times in the course of a year. The subjective noises grew more and more intense, and the hearing power on the right side was completely lost. During the first attack, the patient noticed mouches volantes in his right eye, which have remained permanent, without impairing sight in any way. An ophthalmoscopic examination revealed no abnormity. The examination of the ear showed: Membrana tympani and middle ear normal; bone and air conduction for watch and tuning-fork totally absent; speech and whistling are heard at a distance of 1′ when the left ear is closed.

Though oculists commonly attach no particular pathological importance to the mouches volantes, yet in the above case they were, according to my opinion, in connection with the ear disease, since they had not been present previously, set in during the first attack, and have remained permanent. I am, however, unable to explain this connection.

In the following case of Ménière's disease, the pupil of the suffering side was dilated.

Dr. H., 44 years old, of Frankfort, consulted me on November 11th, 1877. After having suffered for some time from tinnitus and dullness of hearing on the left side, he went, last September, to Ostende. Here a powerful wave struck the left side of his head, taking away his consciousness, as he states, for half a day. When he had recovered it, he suffered three days and nights from intense vertigo and vomiting, and the tinnitus on his left side was greatly aggravated. Both tinnitus and daily seizures of vertigo are still present. The examination showed slight opacity of the mucous layer of the left drum-head, injection of the vessels of the handle, otherwise no abnormity. Hearing by air as well as bone conduction completely lost. During the action of the anode of six Siemens-Halske elements, tinnitus disappears completely, but reappears when the chain is opened. The left pupil is wider than the right.

Dr. Krüger, of Frankfort-on-the-Main, examined the eyes and kindly sent me the following note:

"The difference between the pupils may be explained by the difference between the refraction of both eyes. It is well-known that the pupil is widest in myopic eyes, smallest in hyperopic eyes, and medium in emmetropic eyes; these conditions are not only accounted for by the difference in anatomical structure, but by the requirements of accommodation and the concomitant contraction of the sphincter pupillæ. The right eye of the patient is slightly hyperopic, showing a manifest hyperopia of $\frac{1}{40}$; the left, however, is emmetropic. The remainder of the eyes shows normal conditions; I am therefore inclined to consider the pupil of the left emmetropic eye as normal, and the narrowness in the pupil of the right eye as dependent upon the hyperopia, and therefore would not attach any pathological significance to the difference of the pupils. Further, we should bear in mind that some dilatation of the pupil is frequently the result of contusions of the eye."

Though this exposition of the optical conditions of the eye may account for the dilatation of the left pupil, it is nevertheless surprising that, two weeks later, May 31st, 1878, after the patient had been electrized by Professor Erb—anode treatment of the ear, galvanization of the sympathetic—both pupils were perfectly equal in diameter.

In the two following cases of disease of the labyrinth, which occurred as a complication in the course of chronic aural catarrh, the pupil of the diseased side was likewise dilated without the slightest difference in the refraction of both eyes nor any other demonstrable anomaly of the visual organ, as stated by Dr. Weiss, assistant surgeon to the Ophthalmic Hospital of Heidelberg.

CASE I.—M., 44 years old, merchant of the Palatinate, suffered for some years from progressive hardness of hearing in the right ear which, six months ago, was suddenly complicated by intense tinnitus on the affected side, further with vertigo and vomiting; the vertiginous movements were directed from right to left. These phenomena were considered to be gastric and treated as such. The attacks repeated twice after prolonged railway travelling; since the last attack the right ear is almost completely deaf and the seat of constant noises.

The examination of the auditory organ showed hyperæmia of the handle-vessels, opacity of the mucous face of the drum-head, but no other abnormity worth mentioning. The acuity of hearing on the right side reduced to $V.=\frac{1}{60}$ (voice at $1'$). Different tuning-forks are perceived neither by air nor bone conduction. A loud-ticking watch is heard on contact only. The left ear is normal in every respect.

The right pupil is markedly wider than the left. The mobility of both pupils equal. Other relations of eyes normal.

CASE II.—F. Bernius, of Reinsheim, æt. 42, came to aural clinic February 1st, 1877. Ears affected for three years without any assignable cause. Right ear: impairment of hearing, constant hissing noises, membrana tympani very concave, short process prominent, handle curved and retracted, intermediate crescentic opacity of the posterior half of the membrana tympani. $V.=\frac{1}{60}$, $h.=\frac{1}{\infty}$ (on contact), no bone-conduction. Experiments with tuning-forks (C' and C'') indefinite, with A, decidedly no bone-conduction; headache, vertigo to falling down. Diagnosis: Sclerosis of the mucous membrane of the drum cavity with increase of intra-labyrinthine pressure.

The patient was treated in the dispensary until the end of July by inflations, injections of sulphate of zinc, iodide of potassium, and morphine hypodermically, without any benefit. At home he used leeches and quinine, likewise without benefit. On July 3d, with increasing vertigo and tinnitus, the right pupil was dilated, but an examination in the Ophthalmic Hospital revealed no abnormity to explain the dilatation of the pupil. Symptoms of formication in the left arm and right leg supervening afterwards, made me fear that the whole difficulty might be in connection with the development of a cerebral tumor. I sent the patient to the department of Professor Erb, who minutely examined him, and, after treating him for some time, came to the conclusion that the manifold complaints of the patient, apart from the tinnitus, were no more than hypochondriac symptoms. A neuropathological cause of the difference between the pupils could not be detected. The treatment consisted in ascending stable and unstable currents through the vertebral column, including the sympathetic. Under this treatment the general health of the patient improved temporarily; the inconvenience on the part of the hearing organ increased slowly. August 23d, the patient informs me that he had more tinnitus and vertigo, and fell to the floor several times daily, etc.

Reviewing the cases of the last category, we find that primary and secondary affections of the labyrinth may be complicated both by transitory and permanent disturbances in the eye. We have seen that in primary affections of the labyrinth, which in general we may classify among the exudative processes of the labyrinth, functional disorders occur in the eye which may be accounted for by concomitant disturbances in the circulation of the brain and the retina.

Unexplained remains the case of persisting mouches volantes. Moreover, it is not possible yet to offer a physiological explanation of the dilatation of the pupil of the side on which chronic affections of the labyrinth were present. Future observations will show whether this dilatation was in causal connection with the aural affection, or only a mere coincidence. Thus far, this condition cannot be explained according to the above-mentioned experiments of Cyon, nor by the physiological data relating to the dilatation and contraction of the pupil.

In normal tension the pupil dilates, as is known:

(*a*) By paralysis of the oculomotor nerve;

(*b*) By irritation of the sympathetic.

Paralysis of the sympathetic produces hyperæmia and increased transudation into the interior of the eye, with subsequent increase of the ocular tension and dilatation of the pupil by pressure on the ciliary nerves, as in glaucoma and megrim. This condition is transient. All these particulars are irrelevant in our observations.

Though miscellaneous cases describing one or several unexplainable symptoms offer little satisfaction, I thought I might be entitled to compile them comprehensively, hoping that others might be able to find a physiological explanation, and succeed in supplementing and enlarging our knowledge of the nature of Ménière's disease, an affection which thus far is as little understood as it is deleterious in its determination.

An observation which I recently made has shaken my conviction as to the localization of this disease to the labyrinth, and to the transitory nature of its so-called cerebral symptoms.

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APPENDIX.

For the sake of completeness and the convenience of those of our readers who are not oculists, I will add the following statistical notes:

Annuske,* on the strength of a very extensive literary material and personal observation, states that choked disc is an almost constant companion of cerebral tumor, and, therefore, deserves the first place among all the symptoms of intracranial pseudoplasm. See Förster,† p. 110. H. Jackson,‡ among 23 cases of choked disc, found 17 of tumor, 3 of abscess, 2 of hemorrhage, 1 of softening.—Fõrster, p. 110, l. c.

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* Annuske: Neuritis Opt. bei Tumor Cerebri. Arch. f. Ophth., Bd. XIX., 3, p. 165.

† Förster, pp. 110–112, in Graefe's und Saemisch's Augenheilkunde, Vol. VII., Th. 5. On the Relation of the Diseases of the Nervous System and Visual Organ.

‡ H. Jackson: *a.* Zehender's Monatsbl., 1864, p. 143. From Medical Times and Gazette, 1864, No. 722. *b.* Lecture on Optic Neuritis from Intracranial Disease. Med. Times, Vol. 43, 1871.

The relative frequency of ophthalmoscopic changes of the optic nerve in intracranial disorder is shown in a tabular statement of Heinzel,* which, however, has reference to children only.

He has compiled 63 cases of meningitis tuberc. basil., intracranial tumor, meningitis cerebro-spinalis, œdema meningum, sclerosis cerebri. Among these 63 cases, changes of the optic papilla were found in 47.

Disease.	Neuro retinitis, choked disc, and congestion of the optic nerve.	Atrophy of of the optic nerve.	Normal.
31 cases of meningitis tuberc. basil.	24	3	4
10 cases of meningitis, with tuberculosis of other organs.	4	3	3
14 cases of cerebral tumors.	7	4	3
55 cases.	35	10	10

In 37 out of 63 cases, the autopsy revealed hydrocephalus, and only in 8 was the fundus normal. In all the cases both eyes were affected, if they were affected at all.

Albutt† noticed in 29 out of 38 cases of tubercular meningitis changes in the background. Fõrster, pages 111 and 112, l. c.

HEIDELBERG, End of October, 1878.

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* Heinzel: On the Diagnostic Value of the Ophthalmoscopic Condition in Intracranial Diseases of Children. Jahrb. f. Kinderheilkunde, Bd. VIII., 3, p. 331.

† Albutt: *a.* On Optic Neuritis as a Symptom of Disease of the Brain and the Spinal Cord. Med. Times and Gazette, 1868. *b.* On the Use of the Ophthalmoscope in Diseases of the Nervous System and of the Kidneys, etc. London and New York, 1871.

ABSTRACT FROM AMERICAN OTOLOGICAL LITERATURE, DURING THE YEAR 1878.*

By Dr. SWAN M. BURNETT, of Washington, D. C.

Accumulations which Obstruct the External Auditory Meatus. By Sam'l Sexton, M.D.—*N. Y. Med. Record*, Aug. 17th, 1878.

The following are the *conclusions* at which S. arrives:

Accumulations in the external auditory canal are of frequent occurrence. They are found in all ages.

They are caused by any condition of the system which increases the heart's action and produces subsequent hyperæmia of the ear.

Increased cerebral circulation, induced by mental action or the use of alcoholic beverages, is a cause.

Affections of the mouth and pharynx, including dentition and the decay of teeth, likewise produce hyperæmia of the ear, through sympathetic nerve connection. Inflammations of the middle and external ear are to be ranked as causes.

Accumulations take place from heightened nutrition resulting in increased secretion.

These collections do not *produce deafness* unless they are impacted.

The method of treatment recommended is that usually employed.

Diseases of Ear from Sea-bathing. By Sam'l Sexton, M.D.—*N. Y. Med. Record*, May 4th, 1878.

S. finds that the ear troubles resulting from sea-bathing are found in nearly equal proportion in the middle and the outer ear, least frequently in the membrana tympani. He details also four cases of inflammation of the drum and membrana tympani after taking Russian baths. Some advice to bathers is given, which, if followed, will lessen the chances of these inflammations.

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* Two publications (Mayer, on Sound; A. H. Buck, on Polypi) contained in Dr. Blake's review (see page 512), have been here omitted.

A Contribution to the Study of Auditory Epilepsy. By A. McL. Hamilton.—*N. Y. Med. Record*, Feb. 9th, 1878.

H. relates the case of a boy of 15, stout and apparently healthy, who had scarlatina at 8, followed by a discharge which has continued to this time. Six weeks ago he syringed the ears for the first time. One month ago had first convulsion immediately after syringing. Next day had one not preceded by syringing, but they can be called up by syringing, or even blowing strongly in the ear. Has had as many as fifteen attacks in the twenty-four hours. The vertigo is peculiar in that it is *vertical* instead of horizontal, and he makes backward and forward movements when sitting up in bed, to try to accommodate himself to his imaginary false position.

The membrana tympani is absent on both sides, and there is a congested condition of the mucous membrane of the drum. Tinnitus is present.

Miscellaneous Cases. By D. B. St. John Roosa.—*N. Y. Med. Record*, Feb. 25th, 1878.

a. Polypus in the ear for forty years (?). *b.* Acute catarrh of the middle ear from snuffing water up the nostrils. *c.* Injury to the auditory nerve from a blow of a fur glove. Music sounded *false*. Drum-head sunken. No benefit from inflation. Administration of strychnia followed by improvement. *d.* Injury to cochlea from cannonading. Effects of quinia on the ear. The effects attributed to a large dose of quinia given to relieve a neuralgia were: an intense redness along the handle of the malleus, and a diminution of hearing power from $\frac{8}{40}$ to $\frac{1}{40}$ and $\frac{3}{40}$. Inflation was followed by no improvement. The effects of the quinia passed off. *e.* Inflammation of the middle ear, impacted wax, causing acute inflammation of the external auditory canals and suppuration of the middle ear with polypi.

Medicated Cotton-wool in the Treatment of Ear Diseases. Sam'l Sexton.—*N. Y. Med. Record*, March 2d, 1878.

S. recommends in chronic purulent inflammations, instead of powders as absorbents, cotton-wool impregnated with some one of the following solutions: Borax, 20%; Zinc. sulph., 2 to 5%; Tannin, 5%; Salicylic acid, 5%; Alum, 3 to 5%; Ferri subsulph., 3%. The wool is to be saturated with the solution and allowed to dry. It is then ready for use.

MODIFICATION OF POLITZER'S METHOD OF INFLATION. J. ASCROFT TANSLEY.—*N. Y. Med. Record*, March 16th, 1878.

T., following a method proposed by Dr. E. E. Holt, of Maine, instead of employing swallowing as a means of closing the pharynx, simply causes the patient to close the mouth and make strong efforts to blow.

CONGENITAL AND ACQUIRED DEFECTS OF THE EXTERNAL EAR. LAURENCE TURNBULL, M.D.—*Med. and Surg. Reporter*, April 27th, 1878.

In the first case, a child of nineteen months, there were but three rudimentary portions of the auricle, the two upper being projections of the cartilage, and the lower one having a curved appearance. There was no lobule, and in the space where the concha and meatus are usually found was a plane surface covered with skin, the auditory canal being wanting. Several unsuccessful operations were performed to find a bony meatus, and T. concludes that there must be an absence of that portion of the temporal bone which forms the tympanic ring and the lower side of the bony canal of the meatus, and that the extension backward of the articular and true glenoid portion of the temporal bone is twice its natural breadth. The child evidently has hearing power.

The second case is one where the meatus is covered over by a layer of skin. Hearing good.

The third case is one in which the cartilaginous meatus was narrowed by continuous pressure of a cap-string behind the ear.

THE CONNECTION BETWEEN STOMACHIC AND LABYRINTHINE VERTIGO. By EDWARD WOAKES, M.D.—*Amer. Jour. Med. Sci.*, April, 1878.

W. endeavors to establish this connection as follows: The blood supply of the labyrinth is from the vertebral artery. The nervous supply of this artery is derived from the inferior cervical ganglion. A connection is established between the lower cervical ganglion and the pneumogastric nerve by a fasciculus given off from the latter about the point where the recurrent laryngeal leaves the trunk of the nerve. The stomach and labyrinth are thus brought into intimate relation. If there is any irritation of the stomach, as from undigested matter, this is transmitted in the path indicated to the inhibitory nerves furnished by the lower cervical ganglion to the vertebral artery. Blood pressure in the labyrinth, with vertigo, tinnitus, etc., is the result.

RESTORATION OF THE MEMBRANA TYMPANI. By S. O. RICHEY.—*Trans. Ill. State Med. Soc.*, 1878.

R. details two cases where the membrana tympani was restored after complete destruction, from purulent inflammation, of the middle ear.

EXOSTOSIS OF THE AUDITORY MEATUS; DEATH FROM MENINGITIS. REMARKS. J. ORNE GREEN, M.D.—*Boston Med. and Surg. Journal*, April 18th, 1878.

G. relates the case of a boy whose otorrhœa began at his third year. It continued several years without producing any marked symptoms. It then ceased for six months, then began again, and continued until the time of his visit in 1869, when he was fourteen years of age. One and a half years before, a polypus was diagnosed, but no operative procedure undertaken, astringents being relied on in the treatment. At the time of his visit to G., there was a thick muco-purulent discharge; meatus was two-thirds closed by two exostoses, one from the anterior, the other from the posterior wall; membrana tympani gone; mucous membrane of drum cavity granular; no caries on closest examination. Treated with thorough cleansing and astringents; improved; discharge became scanty; but the exostosis gradually enlarged, so that in 1876 (seven years from first examination) it closed the meatus. Not very long after the complete shutting in of the canal, head symptoms set in which finally ended in stupor. G. then drilled through the exostosis, and trephined the mastoid, and brought the external meatus in connection with the mastoid cells. He found on examination, now, that the osseous wall of the drum was in a carious condition, and a quantity of grumous matter was washed out. Patient died with all the symptoms of a meningitis.

G. thinks that the retained secretion (from closure of the meatus) was the cause of the caries, and that the inflammation was communicated from the middle ear to the meninges of the brain.

THE GROWTH OF FUNGUS ASPERGILLUS IN THE HUMAN EAR. By C. H. BURNETT, M.D.—*Phila. Med. Times*, June 22d, 1878.

B. gives in this paper a detailed description, with macro- and microscopic appearances, of three cases of *Aspergillus nigricans* and one of

Aspergillus flavescens, accompanied with illustrative figures. As regards etiology, his experience has led him to the conclusion that dampness and squalor are not as fruitful causes of the disease as has been supposed. He has observed more cases in those living under good hygienic surroundings. He thinks any dead animal or vegetable matter left in the auditory canal, especially if it be oleaginous, will favor the growth of aspergillus. He relies, in treatment, on instillations of alcohol, at first diluted, after thorough syringing.

FUNCTION OF THE SEMICIRCULAR CANALS. H. GRADLE.—*Chicago Med. Jour. and Examiner*, August.

G. sums up the evidence furnished by experiment and observation on the subject of the function of the semicircular canals as follows:

"1. We are able to perceive the direction, rapidity, and angular extent of a passive rotation.

"2. The organ for this perception is in the head.

"3. Reflex compensatory movements of the muscles of the eyes (and other muscles) occur during a passive rotation for the purpose of maintaining the equilibrium of the body and the correct appreciation of the static condition of external objects.

"4. These compensatory movements do not occur when the vestibules and canals are extirpated and the eyes closed.

"5. Lesions of the semicircular canals are followed by phenomena identical with those seen during dizziness after a rapid rotation.

"In short, we are forced to recognize in the semicircular canals an organ for the perception of rotatory motion."

CHRONIC OTORRHŒA; CARIES OF PETROUS BONE; FATAL MENINGITIS. F. C. HOTZ.—*Chicago Med. Jour. and Examiner*, Oct.

H. records briefly a case where there had been a discharge for fifteen years from left ear. A small polypus was removed, disclosing a carious condition of the bone. There was, at the time of examination, pain and swelling in and around the ear; the swelling, however, subsided, but the patient died two weeks afterward of meningitis.

A CASE OF DEAFNESS FROM A SINGULAR CAUSE, WITH TREATMENT AND RESULTS. By T. E. MURRELL, M.D.—*Louisville and Richmond Med. Jour.*, July.

A brief synopsis of this case is as follows:—Twelve years ago patient (aged 32) contracted syphilis, which was attended with extensive lesions of the soft palate and pharynx. In 1873 he went to Europe and placed himself under the care of Prof. Moos, whose diagnosis was "glutinous granulation of the pharynx and soft palate, which was leading to adhesions which would in time require an operation to prevent complete closure of the pharynx." Catheterization was not possible. Hearing was restored by paracentesis of the membrana tympani and the use of Politzer's bag.

Trouble progressed until 1875–6, when, though the granulations had disappeared, he was unable to breathe through his nose, and his hearing was bad again. At this time he was operated on by Drs. Agnew and Weir, of New York, and fitted with a hard-rubber plate extending along the roof of the mouth to a point midway between the posterior edge of the soft palate and the posterior pharyngeal wall. A canula was attached to this and inserted through an artificial opening in the false membrane, and through this he breathed comfortably, and his hearing power was again restored. In a month's time, having to remove it for cleansing, he found difficulty in reinserting it, and finally was unable to do so, and the opening closed. In this condition he saw Dr. M., who found that on paracentesis of the membrana tympani water could not be forced through the tubes, and from this he judged them to be closed. As the paracentesis appeared to give benefit as regards hearing, a Politzer's eyelet was inserted into each sunken membrana tympani, which had, up to the time of writing, been *in situ* for over a month and were causing no irritation. Hearing power was thought to be "slightly improved."

BULLET IMPACTED IN MASTOID CELLS, EXTRACTED BY TREPHINING THE MASTOID PROCESS, AFTER DETACHING POSTERIOR INSERTION OF PAVILION AND CARTILAGINOUS MEATUS. PROF. GEO. E. POST. —*N. Y. Med. Record, Oct. 26th.*

LIVE WORMS IN THE AUDITORY CANAL—REMOVAL. A. J. PEDLAR, M.D.—*Pacific Med. and Surg. Jour.*, NOV.

A fly got in the patient's ear, but was removed "in two minutes." Pain set in in ten hours. Five days after, six "maggots" were removed by syringing, when all symptoms disappeared.

OTOLOGICAL REVIEW.

By CLARENCE J. BLAKE.

1. D. B. St. John Roosa. Treatise on the Ear. 4th Edition, 1878.

2. Adam Politzer. Lehrbuch der Ohrenheilkunde für Praktische Aerzte und Studirende. Band I. Ferdinand Enke, Stuttgart, 1878.

3. Alfred M. Mayer. Sound. Experimental Science Series. D. Appleton & Co., New York, 1878.

4. S. Moos. Ueber das Vorkommen und die Bedeutung phosphorsaurer Kalkconcremente im Stamme des Gehörnerven. Vortrag, gehalten auf der Versammlung südwestdeutscher Neurologen und Irrenärzte in Wildbad, am 20. Mai, 1878. *Archiv für Psychiatrie*, Band IX., H. 1.

5. V. Urbantschitsch. Zwei Fälle von Durchtrennung der Sehne des Steigbügelmuskels am Menschen. *Wiener Medicinische Presse*, 21, 1877.

6. R. Voltolini. Eine Röhre (Oese) von Hartgummi fünf Jahre in der Paukenhöhle. *Monatschrift für Ohrenheilkunde*, Aug., 1878.

7. R. Voltolini. Ueber die Offenhaltung einer künstlichen Oeffnung im Trommelfell und die ringfömige Canüle. *Monatschrift für Ohrenheilkunde*, Jan., 1878.

8. A. H. Buck. Polypoid Growths in the Ear. *New York Medical Record*, October, 1878.

9. Dr. Jacubash. Bruch des knöchernen Gehörganges in Folge eines Hufschlags. *Monatschrift für Ohrenheilkunde*, Sept., 1878.

1. The publication of the fourth edition of Dr. Roosa's Treatise on the Ear is a gratifying evidence of the interest which is being found in this branch of surgery, and also of the value of this comprehensive text-book.

The principal changes which distinguish this from the preceding editions are to be found in the nineteenth chapter on Diseases of the Internal Ear, a subject which both in itself and from its relation to diseases of the brain affords a wide field for investigation.

In the first part of this chapter, the author draws the important distinction between primary and uncomplicated affections of the labyrinth and those forms of general nervous debility in which the results of a coincident chronic affection of the middle ear would in part suggest the possibility of a labyrinth lesion.

Primary affections of the auditory nerve and labyrinth are comparatively rare, much more so than is generally supposed, and out of three thousand cases observed by the author in private practice, but four per cent could be positively determined as coming within this class. That secondary disease of the labyrinth, that is, disease extending to this part from the middle ear, is quite frequent, the author considers probable, since we know at least that affections of the fenestra ovalis or undue pressure of the chain of bones upon this opening into the vestibule will cause vertigo, nausea, and other head symptoms.

Post-mortem examinations also show that changes in the labyrinth are apt to occur in connection with diseases of the middle ear, even when there is no suppuration or caries, when, as we have seen, the labyrinth is sometimes necrosed and exfoliated. The frequent development of head symptoms in young children in consequence of the acute inflammations of the middle ear accompanying the exanthemata dependent upon the extension of the middle-ear disease through the delicate partition wall which separates the middle ear cavity from the brain or to the labyrinth are also mentioned, and the opinion of Voltolini, which the author is inclined to support, to the effect that there is a primary affection of the labyrinth that is sometimes mistaken for cerebro-spinal meningitis, is quoted.

" After a careful consideration of the history of very many cases of supposed cerebro-spinal meningitis occurring in young children, there is at least a strong suspicion in my mind that Voltolini is correct in this view, and that an affection of the labyrinth may occur in young children and be erroneously supposed to be cerebro-spinal meningitis. It is very much to be desired, for the clearing up of some points in the nature of this disease and its relations to the acoustic nerve and internal ear, that those who are accustomed to examine and treat cases of aural disease should have opportunities of seeing cases of cerebro-spinal meningitis in their acute stages," and as the author very justly remarks, "the bonds between specialism and general practice should be very close if real advance in this or in other directions is to be made."

Under the heading Symptoms is added a description of the symptom of double hearing with the accounts of these interesting cases and in the recapitulation of the chief symptoms of labyrinth disease, an important addition is made in including abnormal sensitiveness to sounds.

Under the heading Injuries, the author calls attention to those remarkable cases of injury to the head followed by hemorrhage from the ear which leave no trace upon the auditory canal or on the membrana tympani, and three cases of this kind are cited, the conclusion being that the blows produced an inflammatory action in the nerve as well as in the meninges of the brain and the parts of the middle ear. To the section on Inflammation of the Membranous Labyrinth, three illustrative cases have been added, and the section on Concussions, to which but half a page was devoted in previous editions, has been much extended.

The circumstances which attend the causation and progress of the so-called boilermaker's deafness are treated at length, and this, together with the discussion of the symptom of improved hearing during the continuance of a loud noise, and the citation of numerous cases, add much to the interest of the chapter.

In regard to the symptom last mentioned, the author does not consider the explanation of Dr. Buck* adequate to explain all the facts occurring in such cases, and especially in one case cited, that of a man who, having lost both ear drums, could hear the sound of the voice when riding in the steam cars, but could not hear the sound of the wheels or the accompanying noises of the train. On introduction of artificial drums (Toynbee's), the hearing for the voice was improved when in a quiet place, but was readily overpowered by other and louder sounds.

Under the heading Quinine are given the experiments of Dr. Hammond and the author, and the result of experiments upon two others with citation of a case of injury to the cochlea from cannonading, with the effects of quinine upon the ear; the conclusion drawn being that the tinnitus aurium and impairment of hearing following the use of quinine depends upon congestion of the ultimate fibres of the auditory nerve in the cochlea.

The section devoted to Syphilitic Disease of the Labyrinth is especially worth of quotation, in its difference from the previous treatment of the same subject. In the third edition, Dr. Roosa says, "The prognosis in disease of the labyrinth, occurring in the course of syphilis, is very unfavorable. I have never seen a case of recovery." The remarks under review may well be quoted in full. The author says, after mentioning secondary affection of the labyrinth consequent upon middle-ear disease in syphilitic cases: "There are cases, however, of disease of the ear occurring as the result of syphilis, when all the marked symptoms are derived from the labyrinth. If diagnosticated at all early in their course, they are susceptible of relief and cure by the free use of mercury and iodide of potassium. My recent experience has been in such gratifying contrast to that which I had had when the first edition of this book was published, that I am very glad to report it for the purpose of illustrating what has just been said.

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* New York Medical Record, July 5th, 1875.

"In the cases now about to be quoted, I think we are perhaps justified in going a little farther in our classification than merely to state that there is disease of the labyrinth. We may perhaps diagnosticate diseases of the cochlea, or at least say that the affection of the cochlea is predominant in certain cases, just as we may speak of diseases of the semicircular canals, when vertigo and staggering are the prominent symptoms. Syphilitic cochlitis may perhaps be a proper name for this class of cases."

Before quoting the cases in question, of which there are seven, tabular conclusions are given, which serve as a guide to the location and character of the lesion.

"1. Disease of the cochlea as of the other parts of the labyrinth usually, although not always, manifests itself suddenly. The patient can definitely fix upon a time when he became deaf and when he began to have tinnitus aurium. This is true even when one side only is affected. The one-sided deafness would not be so quickly recognized, were it not usually accompanied by tinnitus, vertigo, and often by unsteadiness of gait. Sudden loss of hearing and the sudden occurrence of tinnitus, vertigo, and staggering are not, however, entirely peculiar to labyrinth disease, since it is well known that we sometimes, although rarely, have the same symptoms in cases of inspissated cerumen and catarrh of the middle ear. They are, therefore, only of pathognomonic value, in connection with the objective examination and tests.

"2. The tuning-fork is usually heard better or only in the sound or better ear. This would be a much more valuable test were the average powers of exact and objective examination better than we find them among our patients. The value of the tuning-fork is impaired by the willingness of even intelligent patients to believe that they hear all kinds of sounds, no matter how produced, better with the better ear. Then again, if both ears be affected to nearly the same degree, the test has an extremely limited value.

"3. The examination of the membrana tympani and the employment of the methods for inflating the middle ear, will usually give us reasonable conclusions as to the situation of a given disease of the ear, so that at the least we may exclude collections of fluid in the tympanic cavity, in making a differential diagnosis between diseases of the middle ear and of the labyrinth.

"4. The piano, or any very similar musical instrument, will aid us in determining whether or not disease of the cochlea exists. The examination of cases that were unquestionably affections of the labyrinth shows that the power of appreciating low tones is the last to suffer, and the first to recover in most cases of disease of this part of the ear, so that these will be heard when the high ones are either not heard at all, or are heard false or doubled. From our present knowledge of the physiology of hearing, when these symptoms are present, we must conclude that the cochlea is the seat of disease even if it be secondarily affected.

"5. The diagnosis of syphilis of the labyrinth depends in a great measure upon the same kind of evidence as that from which we conclude that a case of optic neuritis or choroiditis is syphilitic, that is to say, the history, and the presence of other symptoms, such as an eruption, mucous patches, etc.

"It should not be forgotten, however, that the occurrence of labyrinth disease, in a person who has probably had the initial lesion of syphilis, even if no other symptoms are present, is a very suspicious circumstance, which should lead to a careful weighing of the indications for and against a mercurial treatment."

The author prefers the term disease of the cochlea to that of disease of the labyrinth when the prominent symptoms are great impairment of hearing, the inability to hear certain tones, and the production of false ones.

Tinnitus is a symptom common to many forms of aural affection, while vertigo and unsteadiness of gait are chiefly to be referred to undue pressure from the base of the stapes upon the semicircular canals and not to disease of the cochlea.

The term "Ménière's disease," which has been very generally applied in the description of labyrinth affections, should, in the author's opinion, be confined to such cases as those in which a hemorrhage into the semicircular canals is found.

The section on Meningitis and Cerebro-spinal Meningitis is increased by the citation of eight cases of deafness following the latter disease, and by the consideration of labyrinth disease occurring coincidently or in sequence of typhoid fever, special disease, and parotitis.

As will be seen from this review, the chapter in question has been largely re-written and considerably increased in value.

2. A work from the hands of a master is always welcome, and the first volume of Politzer's "Lehrbuch der Ohrenheilkunde," which has just appeared, bears the stamp of the same originality and thoroughness which mark the many contributions from an author who has done so much to lay the foundations of the present otological science.

The first volume comprises 372 pages, is illustrated by 106 woodcuts originally prepared for this work by the author or taken from previous communications of his own, and treats of the following subjects: The Anatomical Divisions of the Organ of Hearing; The Anatomy and Physiology of the Sound-conducting Apparatus with Reference to Diseases of the Ear; The Auricle, External Auditory Canal; Membrana Tympani, Middle Ear; Eustachian Tube and Mastoid Cavity; A Review of the Pathologico-anatomical Relations of the Middle Ear; Methods of Examination Objectively of the External and Middle Ear; Methods of Testing the Hearing; General Remarks on the Ætiology, Duration, and Course of Diseases of the Ear, with Reference to Examination of Patients and Analysis of the more Important Symptoms of Disease, followed by the Special Enumeration of the Diseases of the External and Middle Ear and of the Naso-pharyngeal Space and Nasal Cavity. Throughout the first portion of the book, devoted to a description of the anatomy of the external and the middle ear, especial reference is given to the relations of these to contiguous structures, to points in the anatomy which have a particular bearing upon the pathology of the organ, and which are therefore of the most practical importance. This manner of treating the subject makes the introductory portion of Prof. Politzer's work especially valuable to the student of otology, and indeed makes the whole book an impersonation of the author, since it exhibits that method of careful investigation and practical application of observations which mark the lasting influence which he has had upon the development of aural surgery as a branch of scientific investigation.

The individuality of the author is also shown throughout the work, not merely in the reports of his own observations and in the general clearness of the style, but in the evidence of his personal investigation of the subjects quoted from other writers, for which due credit is given. In this respect the field of otological literature has been fairly covered, and the book therefore presents a résumé of our knowledge of this subject up to the present date, with the further advantage of the addition of the author's criticism and expressed opinions, each new fact presented by others having been subjected to his careful analysis.

It would be impossible to note in a review the special points in this book which are most worthy of attention, as in order to do justice to all, much more than the compass of a review would be required. The chapter on the physiology of the sound-conducting apparatus includes much of practical importance in the sixteen pages devoted to it, and with the manner in which the subject is treated a larger space would have been welcome, especially so far as concerns the author's own investigations and those of Buck which he quotes at length, since it is in this direction that we are to look for the foundation of much of our future knowledge of the conservative surgery of the organ of hearing.

Of importance to the practitioner is the chapter on the therapeutic value of the Politzer air douche as compared with Valsalvian inflation and the use of the Eustachian catheter, and the possible consequences of repeated Valsalvian inflation in the production of a hyperæmic condition of the tympanic mucous membrane, and the consequent effect of such a condition upon the labyrinth, are especially worthy of consideration.

In the chapter on the methods of testing the hearing is included the description of the universal acoumeter, the subject of a paper of Dr. Hartmann in these ARCHIVES, which fills the want long felt for a hearing test which may be accepted as the universal standard. This instrument of Prof. Politzer is commendable for its simplicity of construction and for affording a constant tone of constant intensity, by means of a steel bar set in vibration by the blow of a small steel hammer; by the addition of a small steel rod having a metal foot-piece, the instrument may also be used for testing the perception of the sound conveyed through the bones of the head. As the steel bars of all of these instruments are made of uniform size and temper, and are struck by the hammer which is so arranged as to fall only through a certain space, the Politzer acoumeter is an absolutely uniform and invariable hearing test and as such should come into general use as the recognized standard.

The chapters upon the membrana tympani and middle ear and the objective symptoms of disease of these structures is what we should be led to expect from the author of the "Beleuchtungsbilder des Trommelfells," and the volume concludes with a treatise upon the diseases of the nasal cavity and naso-pharyngeal space which is of the greatest practical importance to the aural surgeon. The perusal of the first volume as a whole leads the reader to await with interest the appearance of the second volume.

3. The healthful interest which is growing in the direction of original scientific investigation and which makes the demand for instruction in the several branches of physics in our schools and colleges, is met and given its right direction by the series of experimental science publications, of which the practical and instructive work of Prof. Mayer is one of the best examples.

The difficulties which beset the production of a popular and at the same time throughly scientific book of this kind can be known only to one who has undertaken the task of measuring the comprehension of a widespread auditory of varying degrees of intelligence, and of meeting their demands for the clear and concise rendition and illustration of scientific statements and experiments.

The book of Prof. Mayer, comprising one hundred and eighty-one pages and containing sixty-one woodcuts, is an elementary treatise on sound illustrated by one hundred and thirty experiments, each one of which leads up to and suggests another, many of which are entirely new and original, and all of which have been made repeatedly by the author and by students under his observation.

The simplicity and ingenuity of the experimental illustrations of the subject treated are striking characteristics of the book, and serve to make it in the fullest sense that which it was intended to be—a work of value to teachers and beginners in experimental science. To quote from the author's preface, "the pupil should be taught to read nature in the language of experiment, instructed to guide with thoughtfulness the work of his hand, and with attention to receive the teachings of his eyes and ears. Books are well—they are indispensable in the study of principles, generalizations, and mathematical deductions made from laws established by experiment—but 'Ce n'est pas assez de savoir les principes, il faut savoir *manipuler.*' "

It is precisely that art of manipulating which incites the student to make practical tests for himself and which, while it awakens the desire to make original investigations, places at his disposal the means and methods for the carrying out of his intentions which Prof. Mayer has successfully taught, and which give his book its wide distribution, since it meets a demand for a preliminary education of great practical importance, and of which we see the daily growing need in the medical profession.

4. Boettcher, more than twenty years ago, drew attention to the fact of the frequent occurrence of concretions of the phosphate of lime in the periosteum of the internal auditory canal. According to his observation, these were found in greatest number at the bottom of the internal auditory canal, but distributed also in other portions of the periosteum, and occasionally in the neurilemma of the acusticus. These concretions were not considered as an after-product, occurring frequently in greater degree in persons of middle age than in very old subjects, and Boettcher was of the opinion that, if they caused no immediate disturbance of hearing, still by their accumulation might impair the function of the nerve. Morphologically considered, these concretions were either wholly homogeneous or concentrically laminated, whitish or light-yellow, single or in groups, globular or ovoid. Their structure seemed to be dependent upon their location and their opportunity for enlargement. Chemically treated they effervesced under application of muriatic acid, leaving a homogeneous, cellular or fibrous residue.

Prof. Moos has not infrequently found these concretions, and cites in his paper the case reported by him in these ARCHIVES and also cases reported by Dr. Fester,* and adds an especially interesting case which may be cited at length, of a high grade of deafness of both ears developing with comparative rapidity and associated with severe and continuous subjective symptoms—hyperæsthesia of the scalp, accompanied by neuralgic pains of the head, especially neuralgia occipitalis, insomnia, melancholia, and suicide by drowning.

Pachymeningitis, hyperæmia, and hemorrhage in the osseous substance of both petrous bones, hyperæmia of the greater portion of the mucous membrane of both tympanic cavities; hemorrhagic infiltration of the neurilemma of both and of the nerve-substance of the left auditory nerve. Sclerosis of the investiture of the articulations of the ossicula. Phosphate of lime concretions in the trunks of both auditory nerves, and also in the lamina spiralis membranacea of the left cochlea.

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* Zur Casuistik der Psammone am Centralnervenapparat. Berliner Klinische Wochenschrift, No. 8, 1878.

The patient, a woman forty-four years of age, consulted Prof. Moos in June, 1875. She made use of a conversation tube, without which she could understand only a loud shout, although her deafness was of but three years' duration. The results of the examination were largely negative; there being no abnormal appearance beyond a hyperæmia of the manubrium mallei in each ear. Perception through the bones of the head for both watch and tuning-fork was wanting. Both Eustachian tubes were free. The patient complained bitterly of the annoyance from the subjective noises, but as she had been previously treated by means of catheterization, and so forth, without appreciable result, the hearing steadily diminishing, no local treatment was advised, the case being considered one of disease of the nervous apparatus. In July, 1877, her family attendant Dr. Basler forwarded the two petrous bones, with a note to the effect that the patient committed suicide by drowning in consequence of melancholia, and that on post-mortem examination the dura mater was found firmly and completely attached, and that the bony substance of the cranium had become compact at the expense of the diploë.

Further information of importance was obtained later, stating that the patient was the mother of one child which had died six years previously at the age of four years. Since this first confinement she had had a miscarriage, but no other children. Up to within three or four years she had been in good health, and there was no family history of mental alienation, with exception of a report to the effect of a similar suicide in her family. Her trouble began four years before her death with deafness and singing noises in the head, at which time she once consulted Prof. Moos, who reported no middle-ear disease, but an affection of the nerve. During the four years subsequently, she suffered much from insomnia, for which the bromide of potassium was administered in addition to opium which the patient took on her own responsibility.

The insomnia was caused by general excitability and by neuralgic pains in various parts of the head, principally behind the ears and over the occiput; these were accompanied by febrile attacks, the temperature rising to 39° C. There was, in addition, hyperæsthesia of the scalp, especially in one spot over the sagittal suture, where she could not bear the combing of the hair without loud expression of pain, recently also the patient complained of a weakness of the eyes, and the conjunctiva was occasionally injected, and she complained also constantly of the excessive noises in the head.

The examination of the petrous bones gave the following results: The mucous membrane of the superior and posterior pharyngeal walls and of the fossa of Rosenmüller was hyperæmic and covered with transparent, stringy mucous; the right Eustachian tube not free, the left readily permeable; on inflating the latter, a rattling râle was heard. The mucous membrane of the cartilaginous portion of the Eustachian tube was unaltered.

The dura mater was firmly united to the hyperostotic petrous bone, and the osseous roof of the middle ear and neighboring parts of the squamous portion of both bones showed hemorrhagic infiltration; both external auditory canals were free.

The dura mater of the tegmentum tympani was slightly hyperæmic, that following the fissura petroso-squamosa much injected.

The manubrial plexus and the mucous membrane of the mastoid cavity and the right middle ear, with exception of the cartilaginous portion of the Eustachian tube, was much injected. In the left ear the injection of the manubrial plexus was less, and only the mucous membrane covering the labyrinth wall was hyperæmic.

The intra-tympanic muscles of both sides normal, both round windows normal, both the malleo-incudal and incudo-tympanic articulations, especially the latter on the right side, were but slightly movable. The same condition was observable in the movement of the stapes, especially on the left side, but there was no positive anchylosis. The roof of both vestibules was hyperæmic, and the cavity diminished in size, and the membranous semicircular canals were atrophied.

In the neurilemma of both auditory nerves, up to the entrance into the modiolus, were large masses of phosphate of lime, and in the trunk of the left auditory nerve, fresh hemorrhagic effusion. On cross section of the two auditory nerves were found numberless light-yellow homogeneous bodies, both round and ovoid, which effervesced on treatment with acid without changing their homogeneous appearance. The interstitial neurilemma was also thickened, and a few concretions of phosphate of lime were also found in the lamina spiralis membranacea of the left cochlea.

In reviewing the case, the changes above described may be considered as given by the author as follows:

(1.) The occurrence of the hyperæmia, with exception of that upon the left labyrinth wall and of the hemorrhagic infiltration, may be explained by the manner of death and by the fact that the body was found floating back upward.

(2.) The sclerotic condition of the osseous substance of the petrous bone may be taken as a result of the pachymeningitis.

(3.) The changes in the middle ear, the thickening of the articular covering of the ossicula, and their diminished mobility may be considered as the changes of longest standing; they constituted the primary cause of the deafness, and through the induced intra-labyrinthine pressure of the subjective symptoms, the increase in the intensity of which before death was further caused by,

(4.) The development of the phosphate of lime concretions in the trunks of both auditory nerves. Since in consequence of the formation of these masses there was no atrophy of the nerve-fibres, we are justified in concluding that these concretions acted as a pathologically constant mechanical tetanizing apparatus, and considered as such, it is not surprising that the victim finally sought relief from the symptoms which they evoked in suicide.

5. Urbantschitsch reports two interesting cases of division of the tendon of the stapedius muscle with good results.

The first patient was a woman forty-eight years of age, and not in robust health, who was seized suddenly in the night with an attack of dizziness, followed by insensibility of short duration. Since this attack, the patient had suffered from constant tinnitus and deafness of the left ear, and there was, in addition, a marked cutaneous hyperæsthesia of the left side of the head and a sensation of heaviness, with occasional severe hemicrania, usually worse at night. All of these symptoms increased when the patient exercised herself about her household-work, or occupied herself in reading, to such an extent as to confuse her mind, so that it was necessary to keep a watch upon her.

One year after the first attack, Dr. Urbantschitsch examined the patient, and found the right membrana tympani concave and somewhat opaque. In the left ear there was a perforation of the posterior segment, through which the head of the stapes and the tendon of the muscle could be plainly seen, and on examination with the probe, the stapes was found to be movable only with difficulty; the mucous membrane of the tympanic cavity was white. The ticking of the watch was not heard either through the ear or by bone-conduction, but tuning-forks of various pitch were heard better on the left side. At a distance of three paces, loudly spoken words were heard only indistinctly. After ineffectual treatment of several weeks by means of the air-douche, Dr. Urbantschitsch decided upon tenotomy of the stapedius muscle. Unfortunately, a movement on the part of the patient during the operation prevented the complete division of the muscle. After recovery from the vertigo and insensibility consequent upon the traction upon the stapes, however, the patient was found to hear the same watch at a distance of twenty-two centimetres. The hearing for the voice had also improved, and the former continuous tinnitus had disappeared.

Two days later, the vertigo, pain, and tinnitus returned with great nervous excitability. This condition lasted forty-eight hours, and then subsided ; the tinnitus only recurring from time to time. Fourteen days later, the hearing for the watch was sixteen centimetres, the left side of the head felt heavier to the patient than the right, and the tinnitus was occasionally annoying. On examination, it was evident that the tendon of the stapedius had been incompletely divided, and a second operation was performed, completely dividing the tendon. There was immediate relief from the sensations in the left side of the head, and the hearing increased to nineteen and subsequently to forty-five centimetres. From the time of this second operation there have been only occasional attacks of the vertigo and other symptoms, the pain in the head being general, no longer unilateral, and the patient has been able to follow her usual avocations without hindrance.

The second case was that of a young man seventeen years of age, who had in his sixth year an otitis media purulenta in both ears. There had been since that time diminution of hearing in both ears, especially the left, and in the right ear occasional intense tinnitus accompanied by almost complete temporary deafness.

This patient also complained of a sensation of heaviness on the right side with occasional severe pain increased by any occupation requiring fixed attention.

Examination showed on the right side a large cicatrix in the posterior segment of the membrana tympani, through which the stapes, musculus stapedius, and the fossa of the round window were plainly visible. The watch was heard at a distance of twenty-one centimetres, and loudly spoken words with difficulty at a distance of three paces. The tuning-forks of various pitches were heard only in the left ear from various points in the head, with exception of the lower tones upon the right mastoid process, which were heard in the right ear.

In the left ear, there was decided opacity of the membrani tympani, with calcareous deposits and a perforation in the posterior inferior segment.

As the right stapes was less freely movable than normal, Dr. Urbantschitsch decided upon division of the tendon of the stapedius, which was accomplished with decided improvement in hearing; the watch, twenty-nine centimetres, and low spoken words, three paces, and relief from the sensations in the head.

The same improvement was not noticeable after the preliminary incision of the cicatrix. The perception for the tuning-fork remained the same as before the operation, but in time the general hearing increased for the watch to forty-five centimetres and for a low voice to four paces, with relief from the pain and ability to read or engage in any other close application without inconvenience. Curiously enough, the hearing in the other ear also improved after the operation; the watch, previously heard only on contact, being plainly perceptible at a distance of one centimetre.

6. Voltolini recalls the case which he has previously reported, in which a Politzer eyelet was left in the right middle ear of a young man nineteen years of age, upon whom he operated in July, 1873. This eyelet which he had made for this especial case was of hard-rubber, three millimetres long and one millimetre in diameter, the flange was made so much broader than that of the original Politzer eyelet that no thread for its withdrawal was considered necessary, and as a consequence, when the eyelet subsequently fell into the tympanic cavity, there was no direct means for its removal. Attempts at its removal by means of forceps and otherwise caused so much pain that this was finally abandoned and the eyelet allowed to remain. In June of this year, the patient again presented himself. The left ear, which had not been operated upon, showed the membrana tympani normal and transparent; the right membrana tympani, on the other hand, was opaque and only in spots transparent. Under illumination with sunlight a dark body could be seen through the membrana tympani, lying in the middle ear, which,

from its size, shape, and position could be none other than the eyelet introduced nearly five years previously. The hearing in this ear was somewhat better than it had been five years previously, and there had been no pain or other discomfort in consequence of the presence of the foreign body.

A cut was made in the membrana tympani and the eyelet easily and painlessly removed by means of a hook constructed for the purpose. There was no inflammatory reaction after the operation, and as the opening in the membrana tympani remained, the hearing was improved.

Prof. Voltolini then perforated the left membrana tympani by means of the galvano-cautery and introduced the recently devised aluminium tube to maintain a permanent opening.

7. In regard to the retention of a canula in the membrana tympani, Voltolini is of the opinion that, when unsupported, it will eventually come out, the ring-formed canula also has the great objection that it cannot, on account of its form, be readily cleansed, and that it is inapplicable in cases of considerable prominence of the anterior wall of the external auditory canal.

He has therefore devised a canula of aluminium, straight, from six to nine millimetres long, and one to one and a half millimetres in diameter, with an anterior, posterior, and two lateral openings, which he introduces in such manner that it rests upon the annulus tympanicus, the tympanic wall, and the floor of the inner end of the external auditory canal. Several operations have been performed by this method with good results; in one case the canula has remained in position fifteen months.

Inflammatory reaction following the operation is successfully combated by cold dressings and the instillation of absolute alcohol.

8. Dr. Buck adds the following note on the use of the Blake snare to his paper on the removal of polypoid growths from the ear.*

When the polypus is moderately firm and of large size—so large that the exact situation of the peduncle cannot be readily ascertained, and when at the same time its physical characteristics, color, texture, and mobility justify the belief that it grows from the mucous membrane of the middle ear, the use of traction is preferred, the peduncle in these large polypi being often a mere cord lying in a sinus into which it would be difficult to introduce a loop. In such cases, if traction is made upon the whole mass, this long peduncle is often pulled out entire; whereas, if the mass be simply excised by repeated operations, this peduncle is allowed to remain, is very difficult to heat with caustics, and if not destroyed will almost certainly reproduce another polypus.

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* New York Medical Record, July 27th, 1878.

On the other hand, if the polypus is soft and if the point of origin of the peduncle can be ascertained, it is better to excise the mass by simply drawing the loop into the canula without exerting any traction upon the mass as a whole. When the polypoid growth is situated in the tympanic cavity, proper excision only should be practised. Finally, if the polypus be firm in texture, with a broad peduncle springing from the external auditory canal, excision alone should be employed.

9. Dr. Jacubash reports the case of a soldier who was kicked under the chin by a horse, falling backward and striking his occiput upon the pavement. Hemorrhage occurred from both ears, especially the right, which discharged about a tablespoonful of blood. Half an hour after the accident, the bleeding from the left ear had ceased, but continued drop by drop from the right ear for some time longer.

The hearing was entirely lost in the right ear, and much diminished in the left ear, a watch being heard at only one foot distance and loudly spoken words only at a distance of six paces. The perception of sound through the bones of the head was, however, normal. Fracture of the base of the skull was not diagnosticated, as there were no cerebral symptoms. The treatment consisted of the application of cold-water dressings, and the binding up of the jaw. On the following morning, there was a fluctuating swelling in the neighborhood of each articulation of the jaw, extending upward into the external auditory canals and nearly closing that of the right side. Six days later, the blood coagula were removed from the ears by syringing, with perfect restoration of the hearing. On the tenth day, a splinter of bone was determinable in the swelling; this finally penetrated the lining of the external auditory canal, and being removed, was found to be a triangular splinter from the anterior wall of the canal.

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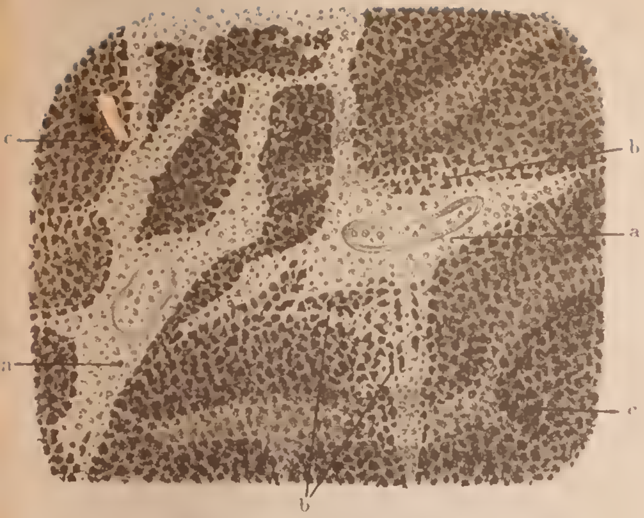

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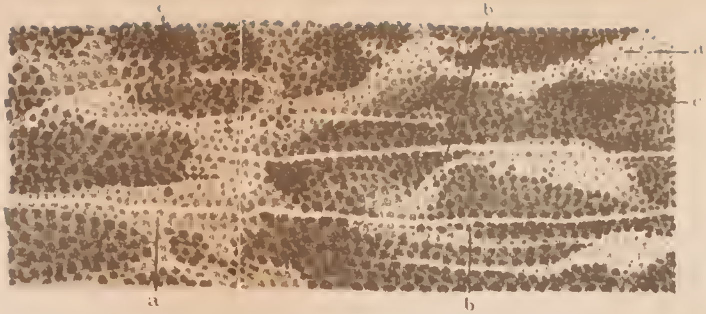

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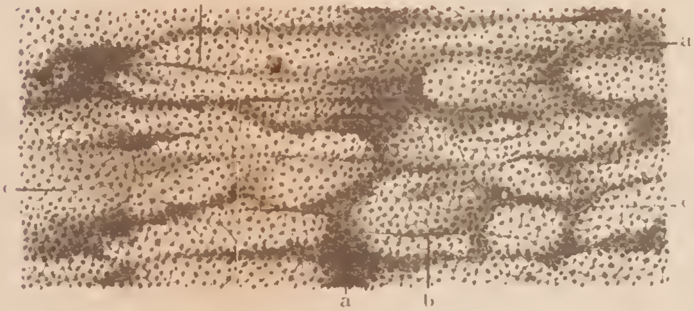

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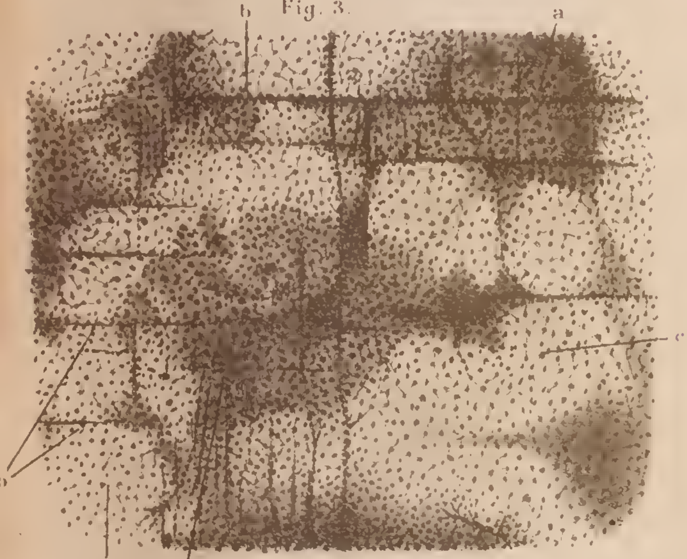

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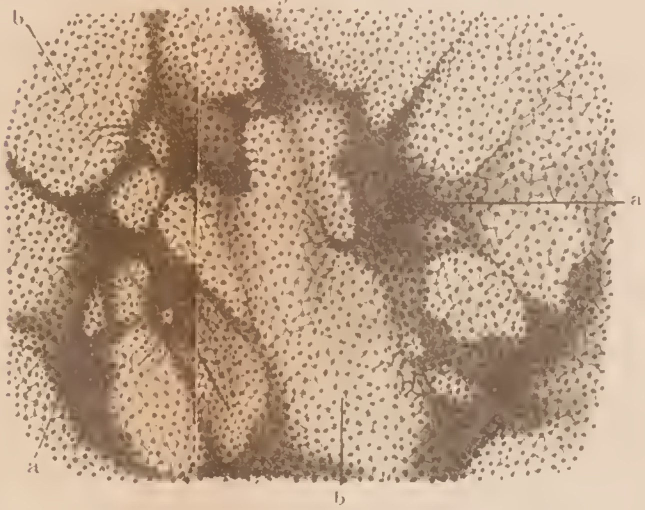

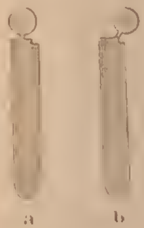

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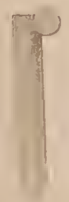

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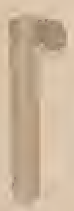

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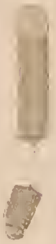

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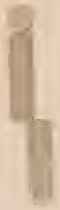

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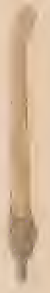

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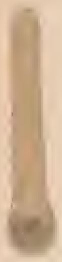

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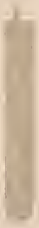

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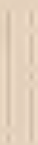

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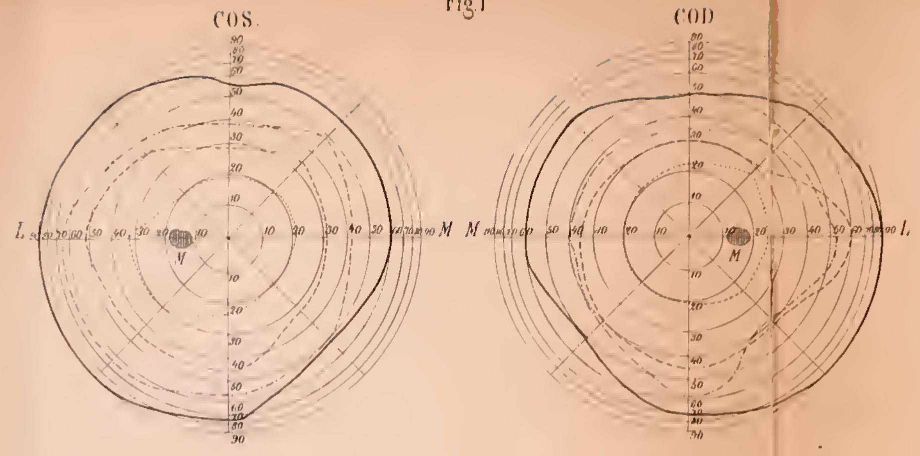

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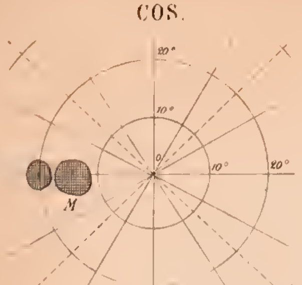

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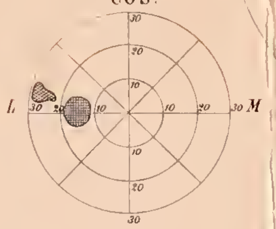

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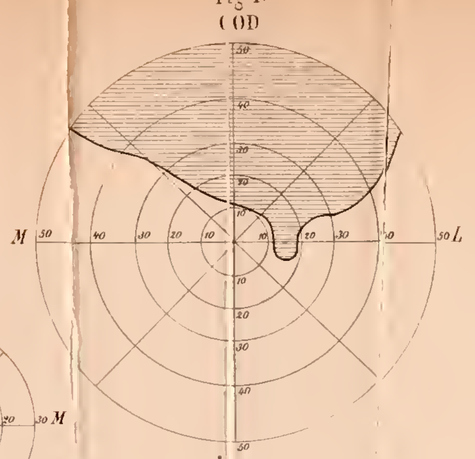

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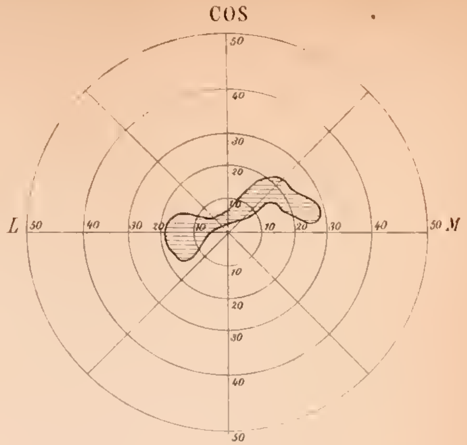

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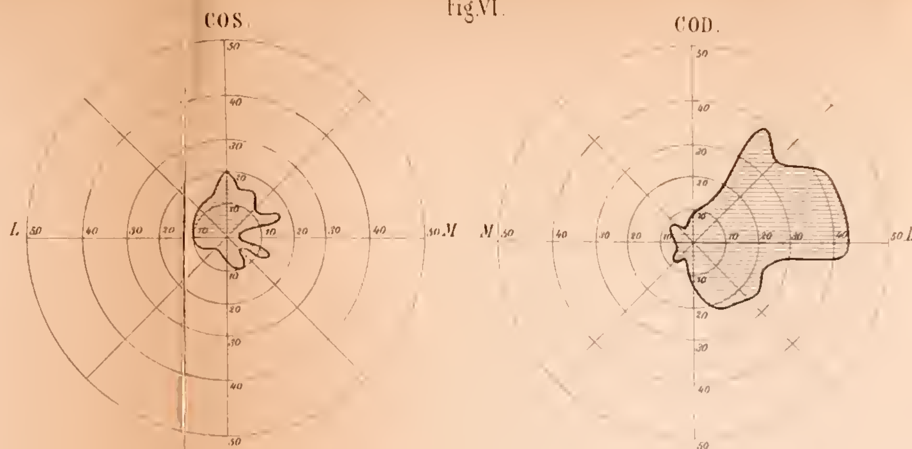

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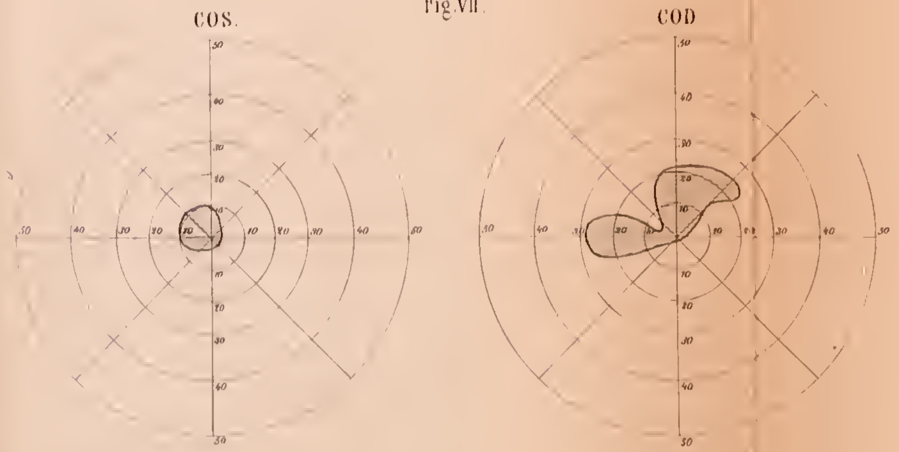

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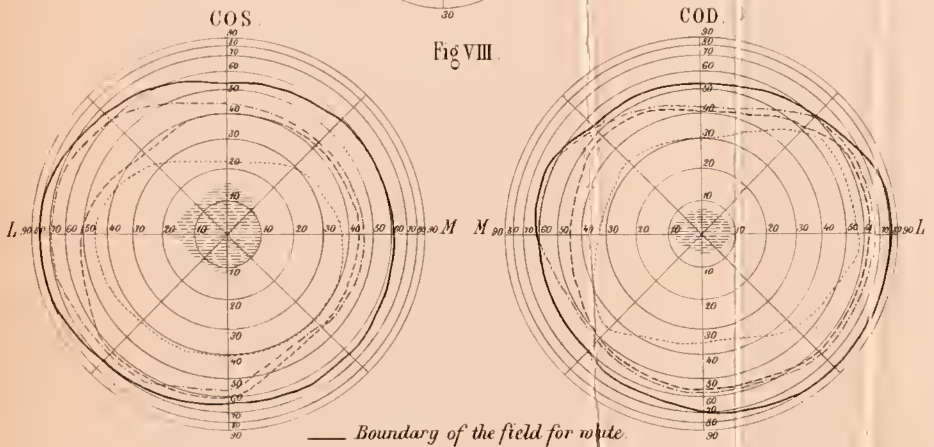

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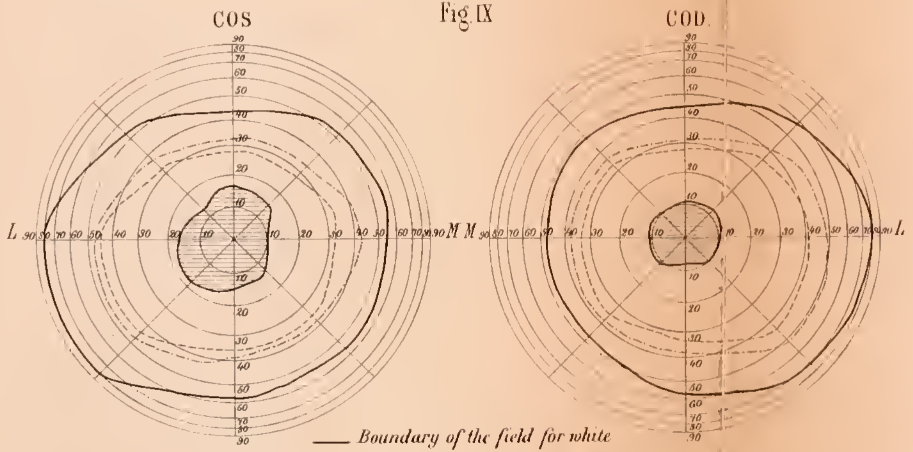

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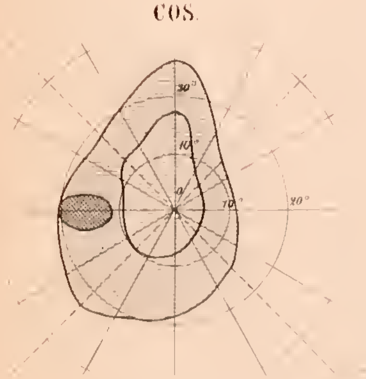

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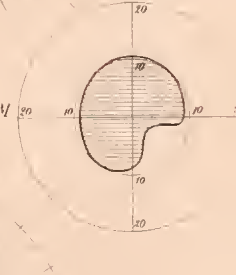

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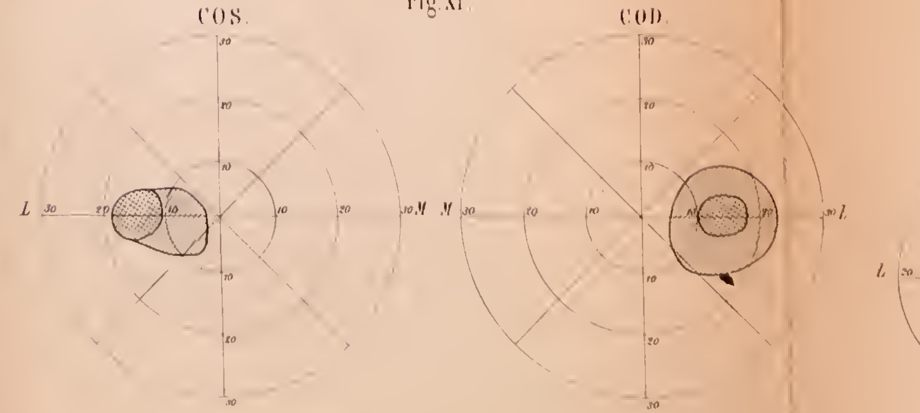

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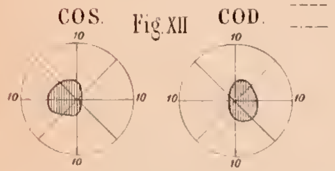

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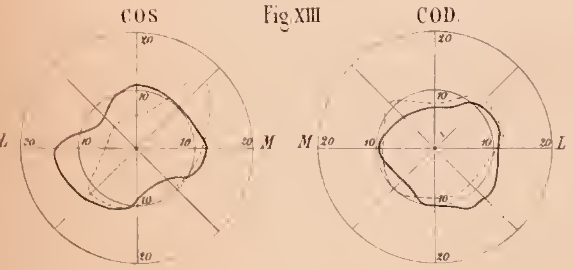

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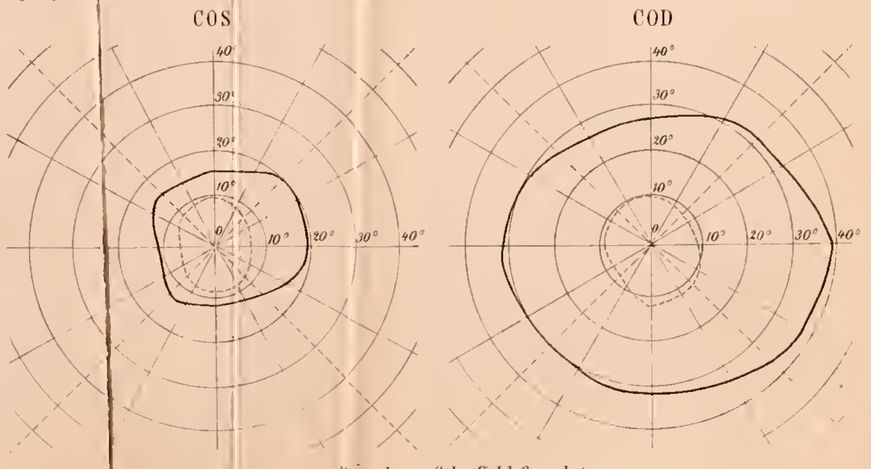

— Boundary of the field for white.
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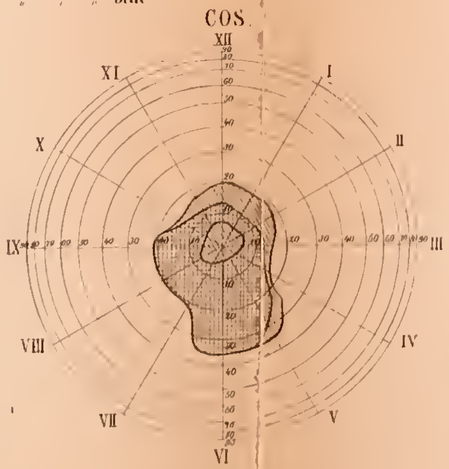


Fig XV^a

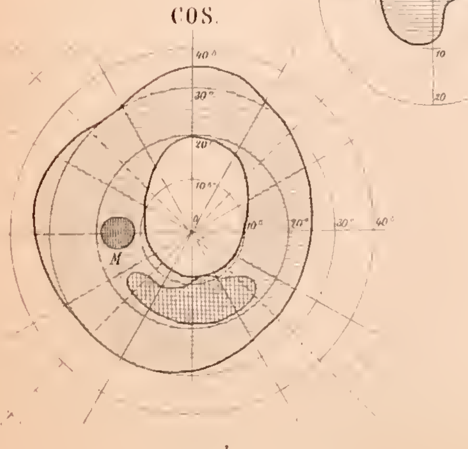


Fig XV^b

Fig. 1.

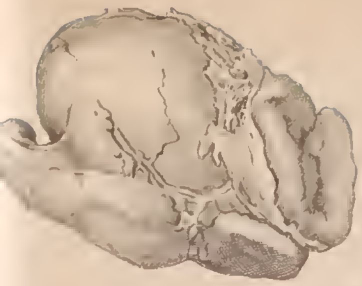


Fig. 2.

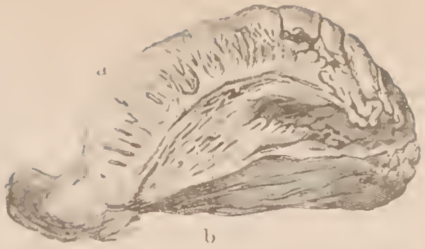
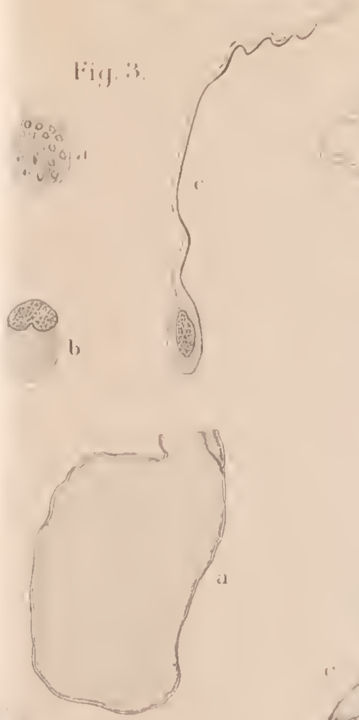


Fig. 3.



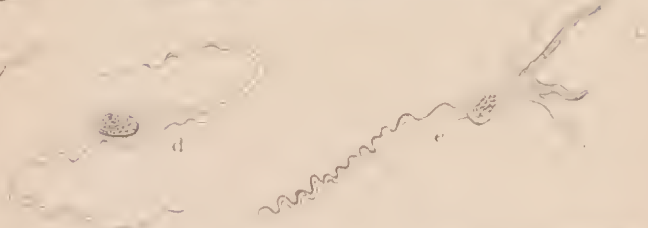


Fig 1

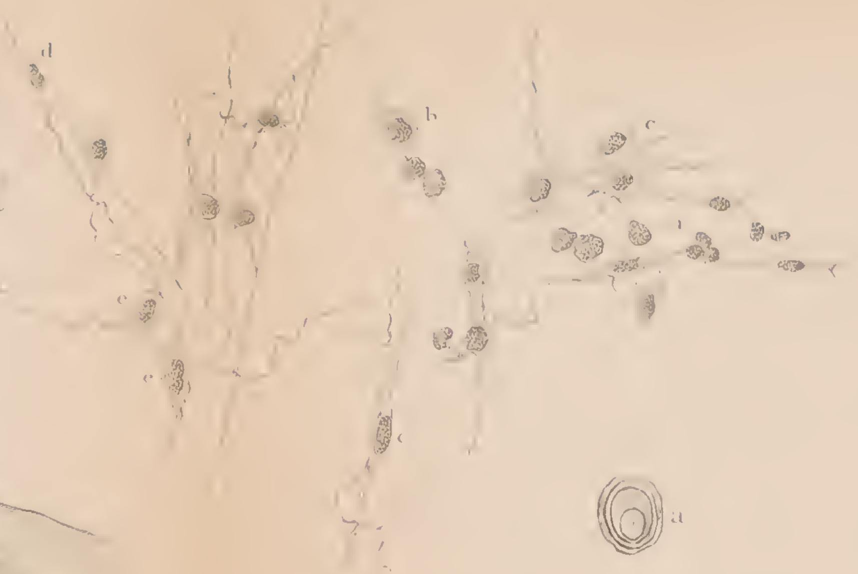


Fig. 7.

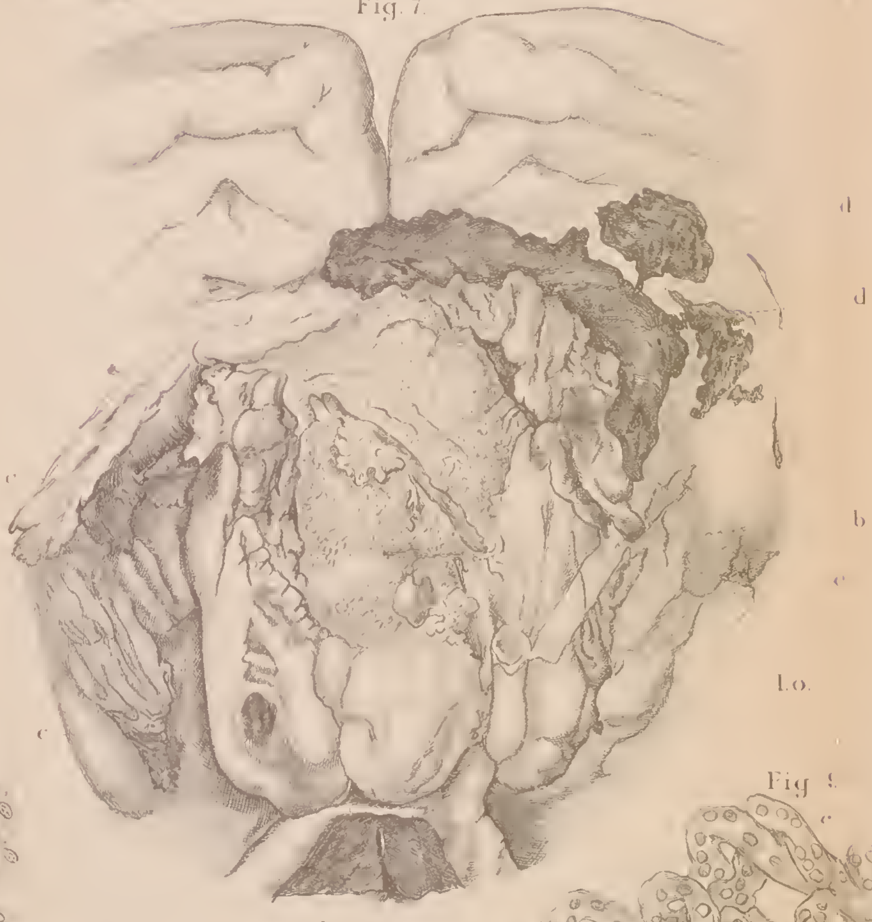
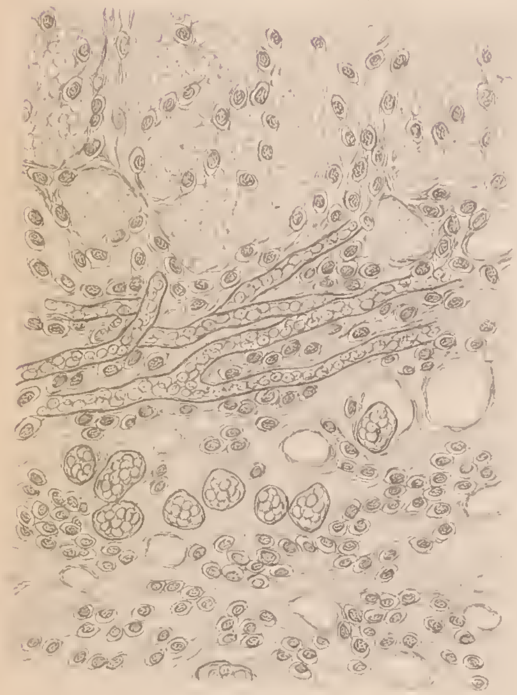


Fig 6.



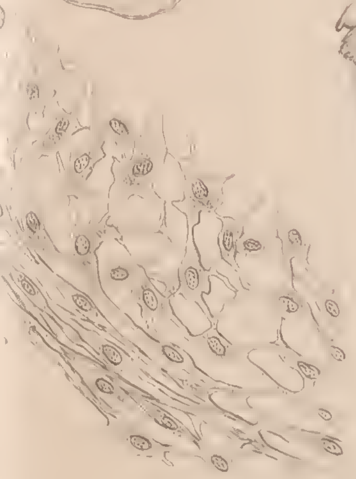


Fig 9

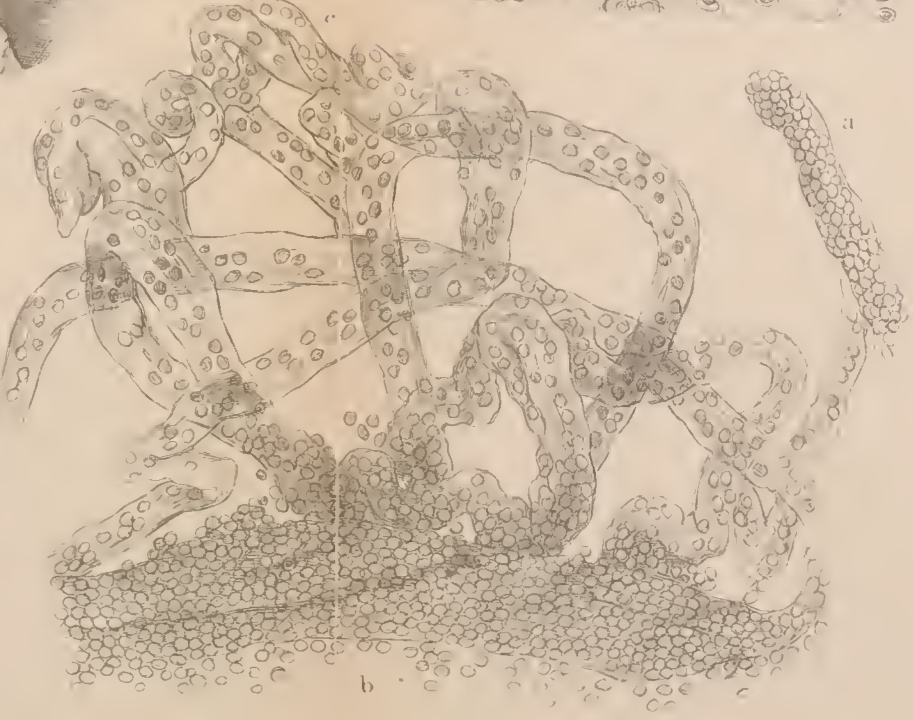


Fig 8.

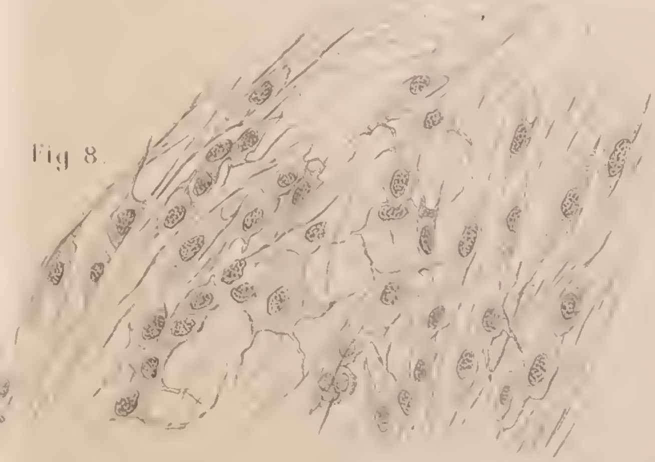


Fig. 1.

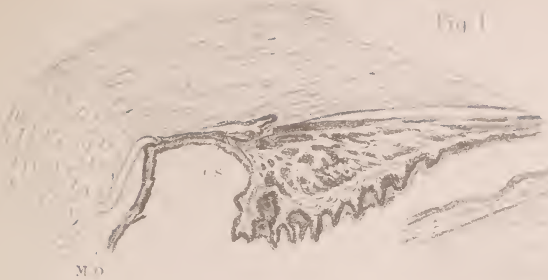


Fig. 2.

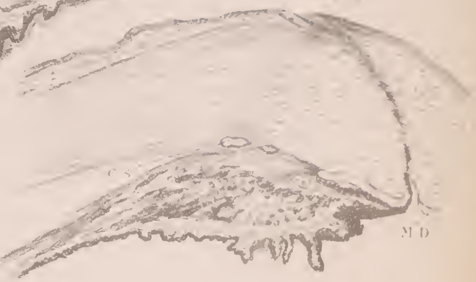


Fig. 3.

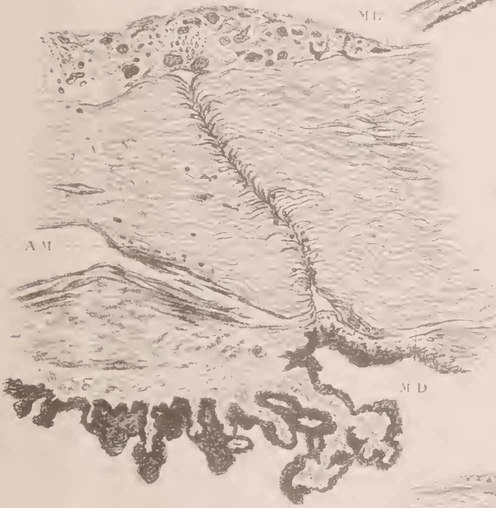


Fig. 4.

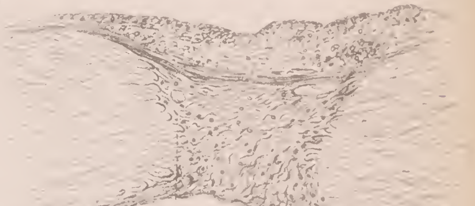
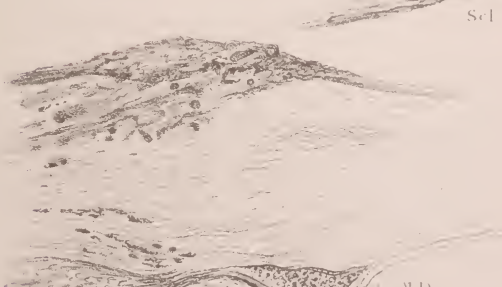


Fig. 5.



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